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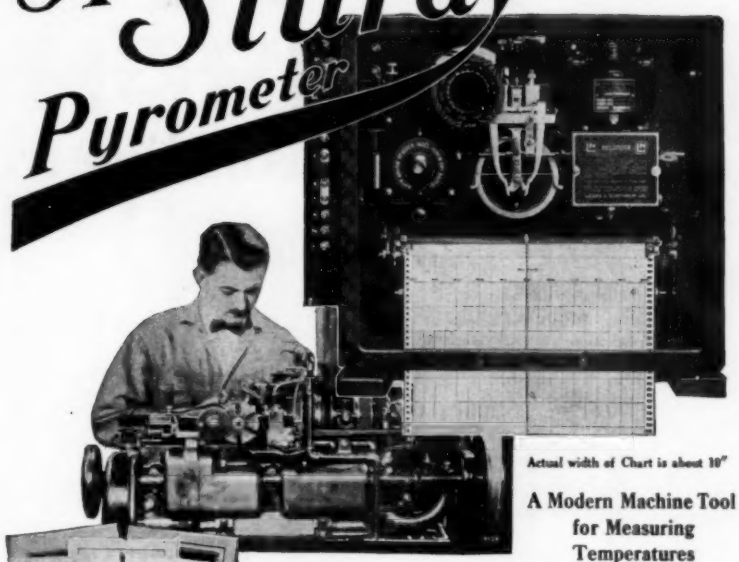

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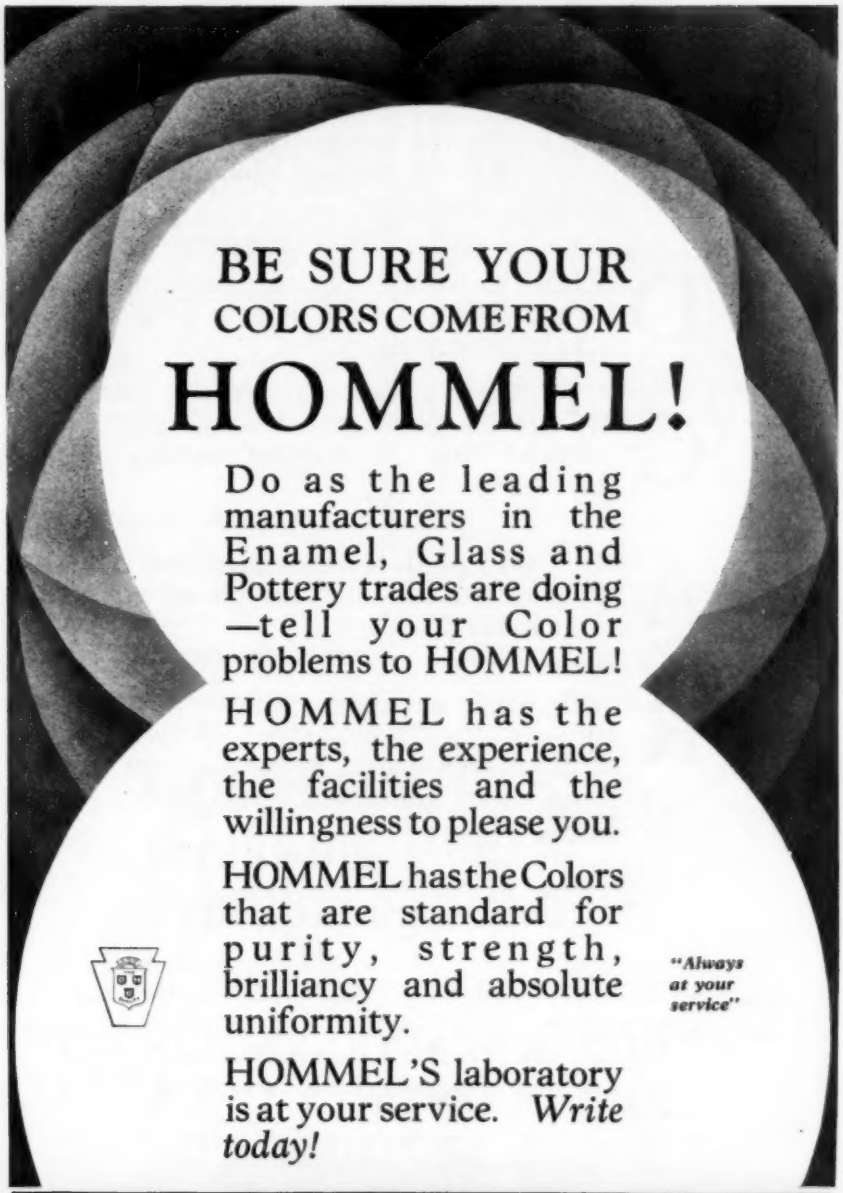
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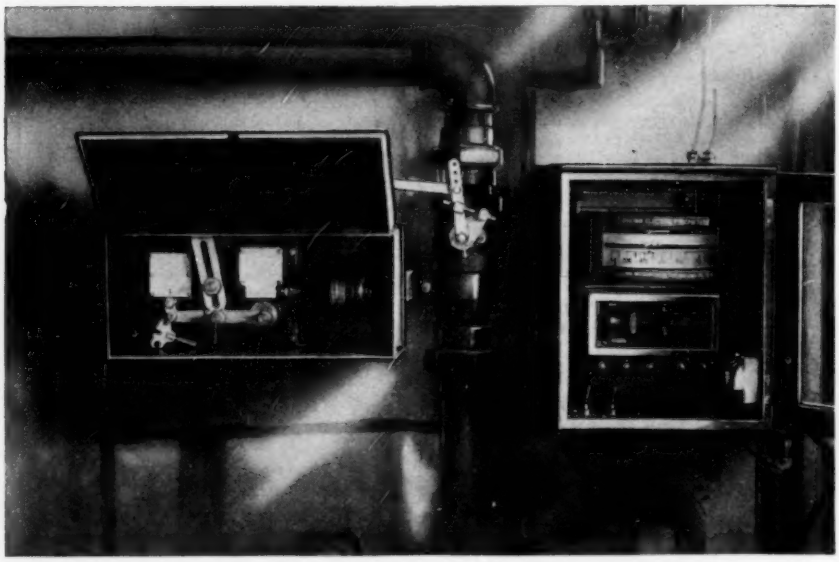

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THE KAOLIN MINERALS[1]

By Clarence S. Ross and Paul F. Kerr

ABSTRACT

A report of an investigation of the clay minerals, nacrite, dickite, and kaolinite is presented in which the methods of study are explained. The optical and physical properties, chemical composition, and X-ray studies of these kaolin minerals are discussed and the results of the study are outlined.

Introduction[2]

Mineralogists and those interested in the industrial use of clay have long been concerned with the identity of the clay minerals, but there has been little agreement in the conclusions reached by various students. Different authorities have even disagreed as to the identity of the clay mineral in ordinary soils and shales. In fact it is still often referred to as kaolinite.

Within recent years there has been a great advance in the technique of studying small crystal grains and within the past ten years it has become possible to identify even such finely-divided materials as the clay minerals. The use of immersion media for the determination of indices of refraction and the compilation of optical data permit a rigorous application of optical criteria to mineral identification (a method carried to its fullest application by American mineralogists). This has recently been accompanied by the development of the X-ray diffraction method for the study of fine-grained crystalline materials. Coördinated studies by optical, X-ray, chemical, and thermal methods now yield criteria for the identification of the clay minerals which are far superior to those based solely on chemical methods, as was the practice when the clay minerals were first described. An investigation by means of these newer criteria materially alters the conclusions formerly held and necessitates the reinterpretation of the minerals of kaolin.

During the progress of the study of the kaolin minerals it has become evident that it is possible to differentiate between the various species by coördinated methods of mineralogical research, even where the materials are very fine-grained or apparently amorphous. Since the clay minerals

[1] Published by permission of the Director of the U. S. Geological Survey. Received December 24, 1929.

[2] An investigation of the clay minerals was begun by Clarence S. Ross in the laboratories of the U. S. Geological Survey. Paul F. Kerr, of Columbia University, has made the X-ray studies and coöperated in writing this report. The chemical analyses have been made largely in the laboratories of the U. S. National Museum, although part of the analyses and all of the dehydration tests have been made in the chemical laboratory of the U. S. Geological Survey. For the past two years the work has been aided by the National Research Council, which has appointed a committee on the study of the clay minerals and has contributed funds to carry on the work of chemical analysis. The investigation of the kaolin minerals has now reached a stage where a report can be made.

are probably more difficult to study than almost any other minerals, it seems not amiss to conclude that practically all crystalline mineral materials are amenable to present day methods of mineralogic research. A complete report of the investigation and a discussion of the origin of kaolin in the light of this new knowledge will be published by the U. S. Geological Survey. Ceramists, however, will be interested in an outline of the general conclusions reached in the study.

Methods of Study

Before the introduction of refined optical methods the rigorous control of the purity of finely-divided minerals was very difficult, and consequently the purity of analyzed clay material has been frequently open to doubt. Some X-ray work has been done, but this has not been comprehensive, and in no instance has it been correlated with fully determined optical and chemical properties. For these reasons in making the present study of the clay minerals, it seemed imperative to make all the observations, optical, X-ray, chemical, and thermal on portions of single samples whose purity has been subjected to the most rigorous tests.

In the course of the study, many hundred samples have been examined, the optical and X-ray properties have been determined on several score of selected samples, and the conclusions reached have been based on four distinct methods of study, chemical, optical, X-ray, and thermal.

Nomenclature

The present work has shown that there is not a single kaolin mineral as has been supposed, but there are at least three distinct minerals. In this paper, the terms kaolin and kaolinite will be used in quite distinct senses. By kaolin is understood a hydrous aluminum silicate rock mass composed essentially of clay material low in iron and usually white, or nearly white, in color. Kaolinite, on the other hand, is one of three distinct minerals. The kaolin-forming clays are hydrous aluminum silicates of approximately the composition $2H_2O \cdot Al_2O_3 \cdot 2SiO_2$ and it is believed that other bases if present represent impurities or adsorbed materials. Kaolinite is the mineral that characterizes most kaolin, but kaolinite and the other kaolin minerals may also occur to a greater or lesser extent in clays and other rocks that are too impure to be called kaolin.

The kaolin minerals herein described are not the dominant constituents in most clays, shales, and soils, as has often been assumed. The literature contains numerous references to kaolinite as the typical clay mineral, although this error has been pointed out by a number of those who have closely studied the subject. Merrill says[3]

---

[3] G. P. Merrill, "What Constitutes a Clay," *Amer. Geol.*, **30**, 318 (1902).

Kaolin as the basis of all clays is the commonly accepted opinion of most writers. The evidence upon which such an opinion is based is largely chemical, and it must be confessed unsatisfactory, so unsatisfactory, in fact, that the present writer has ventured at times to doubt the accuracy of the statement altogether.

Ries[4] says

All clays appear to contain a variable amount of some hydrated silicate of alumina, . . .and even though the statement is frequently made that this silicate is the mineral kaolinite, the fact is at times difficult of proof; indeed, the evidence is clearly against it in some cases. Thus hydrated aluminum silicate was formerly sometimes referred to as the clay substance, or clay base, on the supposition that kaolinite was the basis of all clays. It has been recognized for some years, however, that this view is incorrect, and that a clay may have very little kaolinite.

Even a casual inspection of most clays, soils, and shales, with a microscope, shows that their clay material cannot be one of the kaolin minerals, all of which have a very low birefringence, but is most commonly one of the beidellite-montmorillonite type of clay minerals with a moderately high birefringence. The kaolin minerals are easily differentiated from the more widespread beidellite-montmorillonite[5] type of clay minerals by having distinctive chemical, optical, and X-ray properties. The most obvious differences are a usually lower silica and water content, a weaker birefringence, and characteristic X-ray diffraction patterns for the kaolin minerals.

The problem of nomenclature of the kaolin minerals has been a peculiarly vexing one. The literature is so involved, the descriptions of minerals so incomplete, and the purity of the materials analyzed so doubtful that for the most part it has been very difficult to determine what minerals were being discussed. A review of the literature has no place in a paper of this type, but the general conclusion can be stated rather briefly.

Of the three kaolin minerals, one, the least abundant, from Brand near Freiberg, Saxony, has formerly been rather consistently called nacrite,[6] and so its nomenclature was rather simply solved by reviving this old name and giving it species rank.

In proposing the name kaolinite, Johnson and Blake[7] clearly intended the name kaolinite to apply to the mineral characteristic of commercial kaolins, of which they studied many samples. The kaolinite of Johnson and Blake, however, included nacrite and probably the mineral from Anglesey, although the latter mineral would be excluded from their kaolinite by the optical data given by them. The Anglesey mineral, dickite, which is also

[4] H. Ries, Clays, p. 5 (1927).

[5] Clarence S. Ross and Earl V. Shannon, "The Minerals of Bentonite and Related Clays," *Jour. Amer. Ceram. Soc.*, **9**, 77–96 (1926); also "The Chemical Composition and Optical Properties of Beidellite," *Jour. Wash. Acad. Sci.*, **15**, 467–68 (1925).

[6] A. Brongniart, Traité élémentaire minerales, **1**, 506 (1807); A. Breithaupt, Vollständige Charakteristik des Mineral-Systems, 2d ed., p. 318 (1832).

[7] S. W. Johnson and John M. Blake, "On Kaolinite and Pholerite," *Amer. Jour. Sci.*, 2d Ser., **43**, 351–61 (1867).

well known from Red Mountain, near Ouray, Colorado, and has been found in large masses at Cusihuiriachic, Mexico, seems always to have been included under kaolinite by subsequent writers. It exhibits the most perfect crystals of any known clay mineral and has been fully characterized by previous investigators.[8]

The assumption of a single kaolin mineral and the existence of good optical data for only the Anglesey mineral have led many mineralogists to accept these data as correct for kaolinite. If the name kaolinite be applied to the Anglesey mineral, here called dickite, the optical properties widely assigned to kaolinite would be retained, but this would mean that kaolinite rarely, if ever, occurred in kaolin and most of the references in the literature would be in error. On the other hand if the name kaolinite be retained for the dominant mineral of kaolin, the references to kaolinite will still apply for the most part but the optical properties will have to be revised. The name kaolinite has become so widely used and so firmly fixed in the literature that it seems imperative to retain it for the kaolin mineral that characterizes nearly all kaolin deposits. It then becomes necessary to give a new name to the Anglesey mineral. The study of the Anglesey mineral by Allan B. Dick, work so carefully done that the present paper adds no essential details, suggests the propriety of the name "dickite" for this kaolin mineral.[9]

Optical Properties

The optical properties of the three kaolin minerals are shown in Table I.

It will be seen from Table I that dickite can readily be distinguished from kaolinite by optical means where crystals are available. The acute bisectrix of kaolinite is perpendicular to the perfect basal cleavage, while that of dickite is perpendicular to the edge of the crystal plates when they lie on the *b* faces. The optical character of kaolinite is (−), that of dickite (+). The dispersion of kaolinite is $\rho > v$ and that of dickite $\rho < v$. The angle of extinction of kaolinite is small, usually difficult to determine, while that of dickite is 15 to 20°. There is a marked difference in the angle of extinction for blue and red in dickite, while kaolinite and nacrite do not show this property.

Nacrite resembles dickite more closely than kaolinite, and except in very good crystals the two may be hard to distinguish by optical means.

---

[8] Allan B. Dick, "On Kaolinite," *Mineralog. Mag.*, **8**, 16–17 (1888). Also, Supplementary Note on the Mineral Kaolinite, *Mineralog. Mag.*, **15**, 124–27 (1908). H. A. Mires, *Mineralog. Mag.*, **8**, 25 (1888); *ibid.*, **9**, 4 (1890).

[9] Clarence S. Ross and Paul F. Kerr, "Dickite, a Kaolin Mineral," *Amer. Mineral.*, **15**, 34–39 (1930).

TABLE I

COMPARISON OF THE PROPERTIES OF THE KAOLIN MINERALS

(Similarities)

	Nacrite	Dickite	Kaolinite
Chemical composition	$2H_2O \cdot Al_2O_3 \cdot 2SiO_2$	$2H_2O \cdot Al_2O_3 \cdot 2SiO_2$	$2H_2O \cdot Al_2O_3 \cdot 2 \pm SiO_2$
Crystal system	Monoclinic	Monoclinic	Monoclinic
Orientation of the axial plane, A	$A \perp (010)$, nearly $\parallel (\bar{1}00)$	$A \perp (101)$, nearly $\parallel (\bar{1}00)$	$A \perp (010)$, nearly $\parallel (\bar{1}00)$
Indices of refraction	$\alpha = 1.557$ $\beta = 1.562$ $\gamma = 1.563$	$\alpha = 1.560$ $\beta = 1.562$ $\gamma = 1.566$	$\alpha = 1.561$ $\beta = 1.565$ $\gamma = 1.566$

(Dissimilarities)

	Nacrite	Dickite	Kaolinite
General appearance	Pearly luster, fairly transparent Trilled tabular crystals Wedge-shaped cleavage plates	Transparent, tabular crystals	Translucent to opaque Crystals elongated parallel to c axis Vermicular habit
Orientation of bisectrices	$Bx_a = \wedge$ base normal = 10–12° $Bx_o = Z = b$ axis	$Bx_o = X \wedge$ base normal = 15–20° $Bx_a = Z = b$ axis	$Bx_a = X \wedge$ base normal = 1–3½ $Bx_o = Z = b$ axis
Dispersion	$\rho > v$ rarely $\rho < v$	$\rho < v$	$\rho > v$
Optical character	(−) rarely (+)	(+)	(−)
Angle of extinction on (010) against base	10–12°	15–20°	1–3½°
Angle of extinction for red and blue light	Not different	Red 3° greater than blue	Not different
X-ray diffraction pattern	Distinct for each species		
Dehydration curve			
Staining with dyes	Not readily stained by dyes Not pleochroic	Not strongly stained by dyes Not pleochroic	Adsorbs dyes very strongly, becoming pleochroic

Physical Properties

In habit kaolinite forms vermicular crystals that are commonly warped, twisted, or curved. Dickite occurs as thin crystal plates that form parallel groups which commonly resemble a partly opened book.

Nacrite occurs as complex crystal groups that resemble muscovite.

All three minerals have a hardness of about 2.5 as they scratch muscovite. The specific gravities are not greatly different, but dickite and nacrite are probably slightly heavier than kaolinite. Kaolinite 2.59, dickite 2.62, nacrite 2.5+.

Kaolinite adsorbs dyes readily and becomes pleochroic, while dickite and nacrite do not show this property.

The dehydration studies of the kaolin minerals need not be reproduced here, but they have shown that each has distinct thermal properties. Kaolinite loses its water at the lowest temperature and so has the lowest

temperature stability, dickite loses its water at a higher temperature, and nacrite at the highest temperature of the three minerals.

Chemical Composition

The chemical composition of dickite, nacrite, and most samples of kaolinite is the same as long accepted by mineralogists, namely, $H_2O \cdot Al_2O_3 \cdot 2SiO_2$. Some samples of kaolinite do not conform to this formula, and show evidence of the existence of an isomorphous series that will be discussed in a forthcoming paper to be published by the U. S. Geological Survey.

X-Ray Studies

The kaolin minerals are all hydrated silicates of aluminum, and the ratios of the component oxides as determined by analysis do not differ greatly. Accordingly, X-ray diffraction patterns must contain relatively large numbers of lines of reasonably sharp definition before it is possible to clearly distinguish the various species so closely related in chemical composition. Published X-ray data on the kaolins are inadequate from this standpoint. The technique of X-ray diffraction photography as applied to well-crystallized substances allows the bringing out of measurable diffraction lines representing interplanar spacings well below 0.7 Ångstrom units; but the physical condition of the kaolins, made up as they commonly are of extremely thin and warped flakes, limits the lines obtainable to those of broader resolution. Lines developed in the kaolin patterns are sufficient, nevertheless, to distinguish the minerals from each other, and of course from other clay minerals, in particular through certain striking and consistent dissimilarities in the range between 1.70 and 1.00 Ångstrom units.

The interplanar spacings in Ångstrom units have been computed according to the well known formula for X-ray diffraction $n\lambda = 2d \sin \theta$. The figures given by Duane,[10] Ka_1 0.7078 Å and Ka_2 0.71212 Å for the Ka doublet of molybdenum were substituted for wave-length (λ) in the formula. In the pursuance of the X-ray studies, photographs were secured in an apparatus of special design[11] adapted after the methods of Hull[12] and Debye-Scherrer.[13] The film holders were modified by the construction of an inclined slit system set at 45° to the path of the incident rays and the sample in each case was placed before the final slit. The modification in the slit system, it is believed, produces diffraction lines with a sharper

[10] W. Duane, Nat. Research Council Relating to X-ray Spectra, **1**, No. 6 (1920).

[11] Paul F. Kerr, "The Determination of the Opaque Ore-Minerals by X-Ray Diffraction Pattern," *Econ. Geol.*, **19** [1], 1–35 (1924).

[12] A. W. Hull, "A New Method of X-Ray Crystal Analysis," *Phys. Rev.*, **10**, 661–96 (1917).

[13] P. Debye and P. Scherrer, "Interferenzenan regelos orientierten Teilchen im Röntgenlicht," *Phys. Z.*, **17**, 277–82 (1916).

resolution, an important point in the study of finely divided material, such as clay. All samples were carefully checked with sodium chloride in order to confirm the accuracy of the computation of interplanar atomic spacing. The MoK_β and MoK_γ lines were filtered from the spectrum of molybdenum with zirconia. In view of the fact that the samples were placed in front of the final slit, measurements have been made on the outer edges of the diffraction lines, an improvement over the more frequently used center line measurement. In many cases the diffraction lines are resolved into a doublet consisting of a sharp heavy line due to the wave-length Ka_1, and a less intense line due to the wave-length Ka_2.

During the progress of the study of kaolins the work has demonstrated that it is possible to differentiate between the various mineral species by coördinated methods of mineralogic research even where the materials are very fine grained, or even apparently amorphous. In some samples optical methods alone will identify a kaolin mineral, although in many optical and X-ray methods, and in others a combination of optical, X-ray, and chemical methods have been required. It has become evident that all the methods should invariably be used in testing standards and determining critera for future reference. Since the clay minerals are probably more difficult to study than almost any other series, it seems not amiss to conclude that practically all crystalline mineral materials are amenable to present-day methods of mineralogic research.

Table II shows the X-ray diffraction measurements of the three kaolin minerals. Three columns of figures are given for each mineral. The first column in each instance gives the actual measurement on the film measured in millimeters from the undeviated beam. The second column represents the computed spacing in Ångstrom units. A slight correction has been applied in each figure based upon a pattern of sodium chloride taken at the same time. The third column shows the estimated intensity of the lines.

Nacrite is frequently more coarsely crystalline than the other kaolin minerals and hence must be finely ground in order to produce a satisfactory X-ray diffraction pattern. Specimens, however, when properly ground and screened through china silk (−300 mesh) give a satisfactory pattern which is distinctive from the other kaolin minerals and also from the minerals of the mica group.

Rinne[14] examined nacrite from Freiberg (doubtless Brand, Freiberg, Saxony) by means of X-rays and noted that a difference existed between an X-ray pattern of "Zettlitz kaolin" and one of nacrite. The "Zettlitz kaolin" is probably kaolinite as here defined. The experimental evidence given by Rinne is in accord with our conclusions that nacrite is a mineral

[14] F. Rinne, "Röntgenog., untersuch. an einig feinsertult. Mineral, etc.," *Z. Kryst.*, **60**, 63 (1924).

TABLE II

INTERPLANAR SPACING IN ÅNGSTROM UNITS FOR NACRITE, DICKITE, AND KAOLINITE

Nacrite ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$)*			Dickite ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$)			Kaolinite ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$)		
Film measurement in mm.	Spacing in Å = $10\ cm.^{-1}$	Est. int.	Film measurement in mm.	Spacing in Å = $10\ cm.^{-1}$	Est. int.	Film measurement in mm.	Spacing in Å = $10\ cm.^{-1}$	Est. int.
18.3	4.471	8	18.3	4.471	8	18.3	4.464	10
19.5	4.201	5	19.5	4.201	5	19.5	4.194	10
22.6	3.621	9	21.3	3.846	5	21.1	3.874	5
24.25	3.371	4	22.55	3.631	9	22.6	3.614	6
26.4	3.101	3	23.5	3.491	2	23.9	3.424	5
32.2	2.541	5	24.6	3.336	0.5	25.8	3.069	2
33.8	2.425	10	25.9	3.161	0.5	29.3	2.789	1
35.1	2.335	4	27.5	2.981	2	32.6	2.512	9
39.1	2.095	4	28.8	2.741	2	34.8	2.344	10
41.4	1.980	5	31.6	2.591	5	35.6	2.305	4
42.7	1.920	5	32.4	2.526	8	37.2	2.205	1
45.1	1.820	2	34.0	2.408	1	41.0	2.005	4
49.3	1.671	5	35.0	2.346	10	44.3	1.860	1
55.5	1.480	9	36.9	2.225	2	49.4	1.666	6
56.6	1.450	3	41.2	1.995	8	50.6	1.621	2
60.0	1.368	4	42.9	1.910	1	53.1	1.549	2
62.5	1.318	1	43.9	1.870	2	55.3	1.487	6
65.4	1.273	4	45.6	1.800	1	56.6	1.455	2
67.2	1.230	2	49.7	1.659	9	59.4	1.382	1
68.5	1.209	5	52.7	1.564	5	61.6	1.347	5
70.1	1.179	1	55.2	1.494	8	63.4	1.303	2
72.9	1.134	0.25	56.2	1.469	2	64.4	1.283	3
75.8	1.094	.25	57.4	1.434	0.5	66.9	1.233	4
76.8	1.079	.25	58.6	1.409	1	68.8	1.203	0.5
80.8	1.028	.5	59.7	1.383	1	71.3	1.164	.25
87.0	0.959	.5	62.4	1.323	8	74.5	1.114	.25
91.9	.910	.25	63.9	1.293	3	76.5	1.084	.25
98.1	.854	.25	65.7	1.258	4	79.8	1.041	.25
101.2	.833	.25	66.9	1.236	4	82.1	1.013	.25
106.0	.798	.25	69.4	1.190	3	87.9	0.951	.5
115.7	.737	.25	71.6	1.159	0.5	94.3	.889	.5
121.0	.707	.25	75.0	1.109	2	98.0	.858	.25
			77.1	1.077	1	100.7	.838	.25
			80.3	1.032	2	106.1	.797	.25
			83.9	0.995	1			
			87.0	.960	1			
			89.8	.930	1			
			94.4	.879	2			
			97.6	.859	0.25			
			99.9	.842	.25			
			102.5	.820	.5			
			110.6	.765	.25			
			115.6	.735	.25			

* Corrected against sodium chloride (100) = 2.814 Å. (Measurements in millimeters are given as read on film.) Å measurements include a small correction based on sodium chloride.

distinct from kaolinite and dickite. Strutinsky[15] has also examined nacrite from Crimea by both optical and X-ray methods, and although he

[15] L. B. Strutinsky, "Röntgenograficheskoe issledovanie glin," *Jour. Russ. Phys. Chem. Soc.*, **58**, 314–25 (1926).

gives insufficient data to draw definite conclusions, his work would seem to confirm that of Rinne.

Dickite in most instances occurs in crystals sufficiently coarse to give a spotted X-ray pattern unless the mineral is ground to −300 mesh. Ground samples, however, give the most satisfactory X-ray diffraction patterns of the three kaolin minerals. The lines are sharp and occur in sufficient abundance to give assurance to comparisons. There is a certain general resemblance between the patterns of dickite and the other two minerals of kaolin, but the differences in detail are numerous and make certain that the three actually differ.

McVay and Thompson[16] in writing about the effect of heat upon china clays give a series of X-ray diffraction patterns. They state in the discussion that the diffraction patterns of the National Belle and Red Mountain "kaolinite" agree with each other and with those of the Georgia and English china clays. Study of their table of measurements,[17] however, fails to support this conclusion. For instance, in a pattern for "Georgia raw" one line at 1.62 Å is noted and in "A-1" "china raw" a corresponding line is given at 1.61 Å. In both the Red Mountain and National Belle samples, however (although better patterns in each case), the line is missing. This would indicate a difference between the two sets of patterns of at least one line. Numerous other differences exist, but the measurements given by McVay and Thompson are inadequate to bring them out with certainty. It seems evident, however, that their experiments were carried out on two different minerals. The "National Belle" and "Red Mountain" patterns would correspond with those of dickite, while the "Georgia raw" and "A-1" "china raw" were kaolinite or anauxite, and therefore the conclusion of McVay and Thompson[16] that "kaolinite" (meaning the dick mineral) is the predominating mineral of the clays examined is not justified by their experimental evidence.

More X-ray diffraction patterns have been taken of samples of kaolinite-anauxite than of the other two minerals of kaolin. The X-ray diffraction patterns secured showed no recognizable difference between the pattern of kaolinite and that of anauxite although a large number of patterns of these two minerals were taken under varying conditions of technique, which should have been adequate to bring out any existing differences.

The study of the minerals of this group by means of X-rays has furnished a convenient guide for other methods of investigation; for instance, the results of X-ray studies have in every case been confirmed by optical examination. Several occurrences described as independent mineral species have been found to give the kaolinite-anauxite type of X-ray pattern.

[16] T. N. McVay and C. L. Thompson, "Effect of Heat on China Clays," *Jour. Amer. Ceram. Soc.*, **11**, 829 (1928).

[17] *Op. cit.*, p. 832.

Newtonite, for example, discredited as a mineral species by Foshag,[18] has been examined by means of X-rays and found to give a mixed pattern of kaolinite and alunite.

Conclusions

Kaolin has generally been assumed to be characterized by a single clay mineral, but it comprises at least three distinct minerals, with distinct optical, X-ray, and thermal properties as follows:

(1) Kaolinite, the mineral that characterizes nearly all commercial kaolin and china clay deposits.
(2) Dickite, a mineral first described from the Island of Anglesey, which is rarer than kaolinite but may occur as commercial kaolin deposits.
(3) Nacrite, a mineral from Brand, near Freiberg, Saxony, which is rare and so far as known has not been reported as forming commercial kaolin deposits.

Dickite, nacrite, and most samples of kaolinite conform closely to the formula $2H_2O \cdot Al_2O_3 \cdot 2SiO_2$, but some kaolinite varies from this formula and may belong to an isomorphous series. The three kaolin minerals show distinctive dehydration curves, and break down by loss of water at different temperatures.

The work has shown that the clay minerals and hence probably all other finely divided mineral substances can be studied by present day mineralogic methods.

[18] William F. Foshag, "The Identity of Newtonite and Alunite," *Amer. Mineral.*, **11**, 33–35 (1926).

A SMALL GAS-FIRED LABORATORY FURNACE[1]

By F. H. Norton and C. L. Norton, Jr.

ABSTRACT

There is described a small furnace, particularly suitable for experimental work in ceramics. This furnace is unique in that temperatures sufficiently high for nearly all operations in ceramics can be obtained by the use of a standard Méker burner. The temperature can be brought up rapidly and can be held steadily. The construction of the furnace makes it comparatively simple and inexpensive.

Introduction

The furnace described here was designed for a small gas-fired laboratory furnace capable of attaining high temperatures. A furnace fired with an atmospheric burner was decided upon because it has the advantage of simplicity over those fired by burners using compressed air or gas, and it can be left to burn unattended with safety. It also has a small bulk and is cool and convenient to work around, compared with other furnaces of similar capacity.

Description of Furnace

The size of furnace here described will take a Dixon No. 0000 crucible. The material to be heated or melted is placed in this crucible, but larger objects can be set directly in the furnace in place of the crucible.

Shell and Frame A cross-section of the furnace is shown in Fig. 1. The base (*A*) supports a standard (*B*) which holds the lower furnace shell by the clamp (*C*). The upper shell is attached by a similar clamp to a loose sleeve (*D*) on the standard. This sleeve is prevented from sliding down by a pin (*E*) in the standard, which engages a notch in the lower end of the sleeve. A handle (*F*) on the upper shell allows it to be swung aside to open the furnace, the notch and pin raising the cover slightly from its neutral position. The stack (*G*) is attached to the upper shell and by the clamp (*H*) to the sleeve so that it moves with the upper shell.

Burner The burner (*I*), a standard 35 mm. Méker burner, sets on the block (*J*) so that the burner may be lowered down out of the furnace. The top of the burner extends into the furnace a short distance, with an annular clearance for the introduction of secondary air. Above the burner the furnace chamber flares out to take the crucible supporting disk (*K*), which has radial notches allowing the flame to pass around the crucible (*L*). The upper shell contains the cover which encloses a double passage for the flue gases to pass to the stack.

[1] Presented at the Annual Meeting, American Ceramic Society, Toronto, Ont., February, 1930. (Refractories Division.) Received December 30, 1929.

Refractory Lining Probably the most important feature of this furnace is the refractory of which it is constructed. This is a pure kaolin refractory made highly porous in order that it may act as an insulator as well as a refractory. The properties of this material are listed below:

Weight for a standard brick	1.6 lbs.
Density	0.43 g./cc.
Reheat shrinkage (5 hrs. at 2550°F)	0.4%
Thermal conductivity at	
400°F	1.4
800	1.8
1200	2.1
1600	2.6
2000	3.1

The temperature is the mean temperature of the specimen and the conductivity is expressed as B.t.u./sq.ft./in./1°F/hr.

The resistance to temperature change is better than that of an average fire brick, but on account of its high porosity its resistance to slag is naturally low. The material can be readily worked with saw, drill, or file, or can be turned in the lathe. Due to the high permeability of the refractory it is in some cases desirable to coat the inner surface of the furnace with a thin kaolin cement.

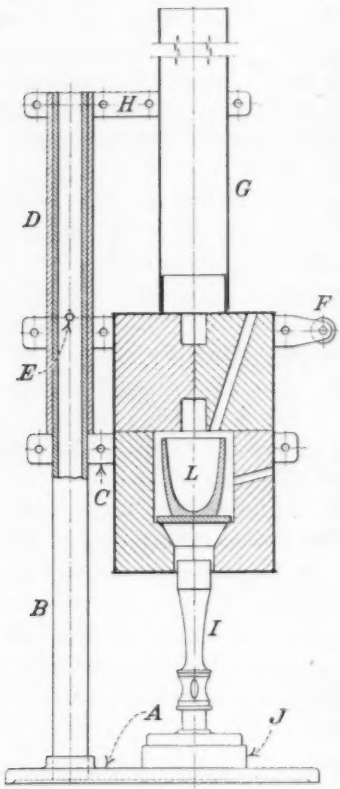

FIG. 1.

Principles of Design The design of the furnace described here was carried out with the view of obtaining the highest possible temperature with an atmospheric type of burner, that is, a burner where the primary air is drawn in by the inspirator action of the gas jet.

The atmospheric burner, even when carefully designed, cannot carry in sufficient primary air for complete combustion with the usual gas pressure of 3 inches of water. Even if the correct amount of air could be introduced, there would be danger of a snap back. Therefore, the atmospheric burner must be supplied with secondary air. This can only be done by the use of some outside agency. The simplest method of supplying this extra air is to use a stack to maintain the furnace under reduced pressure. It is also

necessary to mix the secondary air as well as possible with the flame. This is done here by introducing it closely around the flame and baffling with the crucible support.

After supplying the correct amount of secondary air to the burner, it is necessary to so design the gas passages in the furnace that the maximum temperature can be attained at the desired point. This is accomplished by increasing the gas velocity at the section where the high temperature is desired; but at the same time the resistance to flow must not be increased beyond the capacity of the stack to handle the required volume.

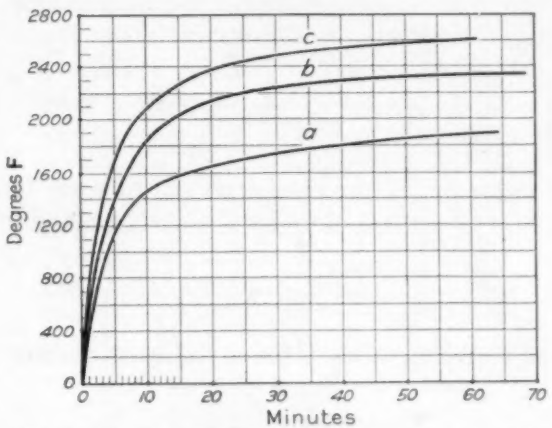

FIG. 2.—Empty crucible. Gas pressure equals $5^1/_2$ inches water.

The importance of this baffling can be strikingly brought out by operating this furnace without crucible or supporting ring. The maximum temperature is lowered some 500°F.

Another important factor in attaining a high temperature is the prevention of the loss of radiant energy out of the furnace. This loss will occur from any opening in the furnace, such as the burner opening, the sight-hole and the exit flue. It is difficult to change the size of the burner hole, but the exit loss can be eliminated by the use of a curved passage as is done in this furnace. The sight-hole can be kept very small. In most cases satisfactory readings can be taken with a diameter of $^1/_8$ inch.

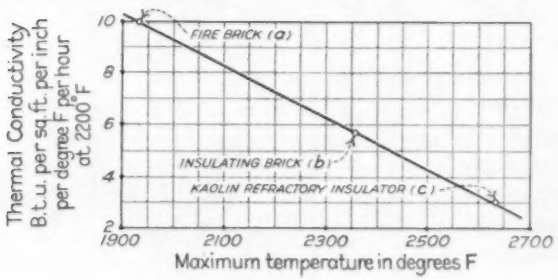

FIG. 3.

Perhaps the most important consideration in reaching high temperatures is the reduction of the heat flowing through the furnace walls. In a refractory-lined furnace this may be accomplished by surrounding the refractory with a thick layer of insulation. In the case of a small furnace

this increases the outside area and makes it difficult to prevent heat conduction along the refractory which lines the inlet and outlet passages. Actually, the insulation of a small refractory-lined furnace of the size dealt with here resulted in a very small increase in temperature.

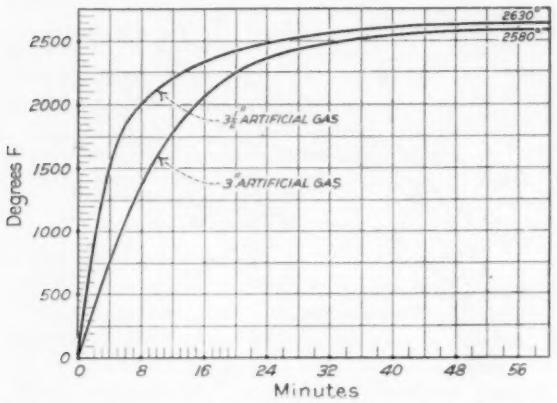

FIG. 4.—Heating curves for furnace containing a No. 0000 graphite crucible and 100 grams of grog.

The ideal arrangement is to have the furnace lined entirely with a good insulator so that the high temperature is confined only to the inner surface of the furnace. The recent development of a superior insulating refractory allowed this result to be attained, and it is mainly due to this that the high temperatures are reached. This is brought out clearly by the curves in Fig. 2, which are the time-temperature curves of three furnaces made according to Fig. 1. Furnace (*a*) is lined with ordinary firebrick material (no insulation), (*b*) with a commercial high temperature insulator, and (*c*) with the kaolin refractory insulator. The maximum temperatures reached were plotted against the thermal conductivity of the various materials as shown in Fig. 3. A straight-line relation is indicated.

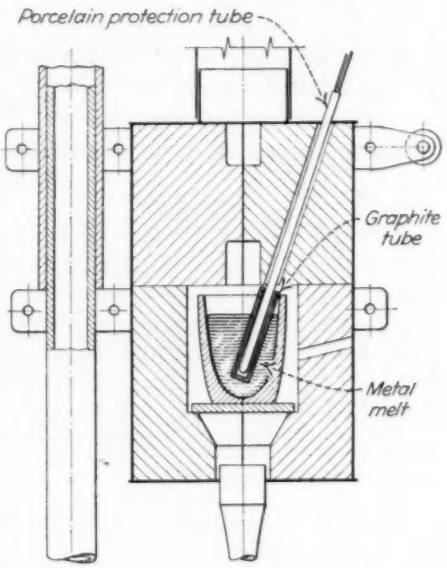

FIG. 5.—Diagram showing method of thermocouple calibration.

In brief, to obtain a high temperature with an atmospheric burner we must have:

(1) A maximum amount of inspirated primary air, well mixed with the gas.

(2) The correct amount of secondary air, well mixed with the flame.

(3) A minimum area of passages opening directly out of the furnace chamber.

(4) A refractory for the furnace with the maximum insulating properties.

In the design of this particular furnace a great number of experiments were made by varying the area of the passages, the thickness of the walls, and the height of the stack. The best results can only be obtained by a close adherence to the correct dimensions.

Performance

The rate of temperature rise with this furnace for two gas pressures is shown in Fig. 4. Fifteen to thirty minutes is sufficient to reach a working temperature. The gas pressure has no great effect on the maximum temperature reached if it remains above 3 inches. The furnace may be held at a steady temperature as low as 1000°F. A valuable property of this furnace is the constancy with which it can maintain a temperature over a long interval of time. If the gas pressure is held constant with a pressure regulator the furnace temperature can be held within ±10°F for firings of several days.

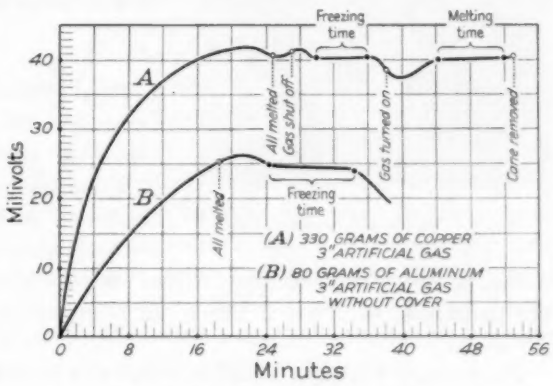

FIG. 6.—Couple calibration curves.

This furnace is convenient for melting samples of glass, glazes or non-ferrous metals. The crucible will contain about 350 grams of copper, 90 grams of aluminum, or 75 grams of glass. The time required to melt a full crucible of various materials with a 3-inch gas pressure are given in the following table:

Material	Time to Melt
Aluminum (cover off)	18 (min.)
Copper	25
Brass or bronze	20
Cast iron	30
Glass	19

It should be noted that the performance of this furnace is given when used with artificial gas. Natural gas will not give as good a performance due to the fact that an atmospheric burner cannot carry in enough primary

air to burn it properly. The maximum temperature when using natural gas is about 2300°F. Higher temperatures can be obtained by using a blast burner.

The temperature in the furnace is generally measured by means of an optical pyrometer sighted through a small sight hole. Care must be taken, however, to keep the hole small or enough cold air will be drawn in to appreciably cool the side of the crucible. Thermocouples may also be used for measuring the temperature, especially if a record is desired. They are not generally as convenient, however, as the optical pyrometer, except at low temperatures.

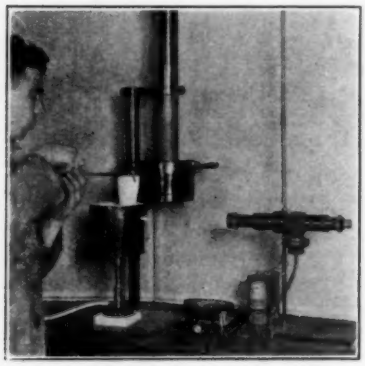

FIG. 7.—Melting a bronze alloy.

Uses

This furnace is particularly adaptable for the calibration of couples from the freezing points of metals. The method of inserting the couple is shown in Fig. 5. Cooling curves with aluminum and copper are shown in Fig. 6, which indicate ample time for obtaining a good freezing point. The quickness with which the metal is melted is a great convenience in this work.

The furnace has been found convenient for making melts of nonferrous alloys (Fig. 7). The neutral atmosphere prevents oxidation, and sufficient metal can be melted to cast a test specimen. Glass, glazes, and enamels can be readily melted. Small specimens of ceramic bodies can be fired in this furnace, which has been found very convenient for research work of this nature. Heat treating of ferrous alloys can be conveniently carried out on small samples. The furnace is also of use to the chemist in all types of high temperature combustion work.

The development of this furnace was carried out through the Division of Industrial Coöperation and Research at the Massachusetts Institute of Technology on behalf of the Babcock & Wilcox Company.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
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AN ELECTRIC SPALLING FURNACE[1]

By Henry N. Baumann, Jr.

ABSTRACT

An electric spalling furnace, heated by means of a graphite resistor and holding twelve test brick at a time, is part of the equipment for the routine testing of refractories in the Research Laboratory of The Carborundum Company at Niagara Falls, N. Y. It is more compact, more easily handled and repaired, more closely controlled, free of flame impingement, and much to be preferred to the fuel-oil fired type of furnace which it replaced.

Introduction

This furnace, by reason of its design and method of operation, is successfully used to test the spalling properties of refractories under conditions which eliminate such interfering factors as gas penetration, variable furnace conditions, and flame impingement always present in gas and fuel-oil furnaces. It forms a compact, easily built apparatus, is economical to operate where electric power rates are low, requires only a small amount of attention and fits nicely into a scheme of routine testing.

While there is at present no accepted standard method of testing for spalling, the A.S.T.M. tentative test, or some slightly modified form of it, is generally used. In the Research Laboratory of The Carborundum Company, the test brick are heated to 1350°C and subjected to an air blast for ten minutes; this practice has been adhered to for years and is substantially the method described by Hartmann and Hougen[2] in their pioneer paper on the physical characteristics of specialized refractories.

An air blast is used in preference to the water-quenching method commonly employed in testing clay refractories for spalling, the air-blast method unquestionably simulating average refractory service conditions better than a water quench, and where refractories of such widely different chemical and physical properties as those of clay, silicon carbide, fused alumina, etc., are being tested, cooling in a stream of air gives the better basis of comparison.

Norton,[3] in referring to a modified form of the A.S.T.M. test employed by him in which he made use of a stream of air for cooling, though using a much higher temperature than usual, states that "a very careful comparison between this test and actual service conditions has been made, and the agreement has been found to be excellent."

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[1] Presented at the Annual Meeting, American Ceramic Society, Toronto, Ont., February, 1930. (Refractories Division.) Received September 12, 1929.

[2] M. L. Hartmann and O. A. Hougen, "Physical Characteristics of Specialized Refractories," *Trans. Amer. Electrochem. Soc.*, **37**, 707 (1920).

[3] F. H. Norton, "A General Theory of Spalling," *Jour. Amer. Ceram. Soc.*, **8**, 37 (1925).

Description of Furnace

The furnace details are shown in Fig. 1 (A, B, and C). Figure 1 (B) is a vertical section longitudinal partly through the resistor and partly through the test brick chamber. The resistor is a slotted Acheson graphite slab, $1^1/_2$ by 6 by 48 inches, supported at the ends by the walls and by iron uprights and in the center by a graphite block. The slots are so distributed that a uniform temperature can be maintained along the entire length of the test brick chamber. The method of protecting the resistor from oxidation is best shown in Fig. 1 (C) a vertical cross-section, the coke, preferably

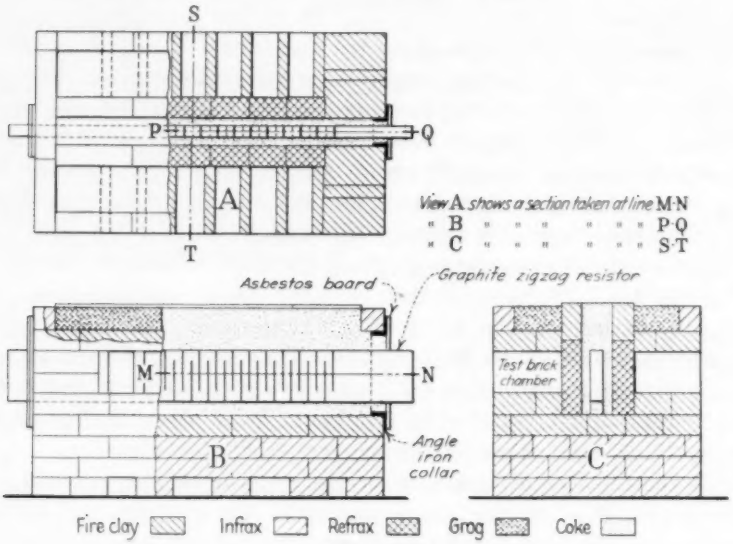

FIG. 1.

petroleum coke, entirely surrounding the resistor and the furnace being open at the top so that new coke can be added as the old slowly settles down and is oxidized. Figure 1 (C) also illustrates well the method of conducting heat to the test pieces. Figure 1 (A), a partial horizontal section through the resistor and test brick chambers and a partial top view of the furnace, shows the twelve test brick chambers.

For the walls between the resistor and the test brick chambers, only such refractories as "Refrax"[4] or other high silicon carbide brick can be used, as the coke-filled space between the resistor and the wall is highly reducing, and other brick, particularly those containing appreciable amounts of silica, would be quickly disintegrated. The inner side of the Refrax wall was covered with the most refractory type of silicon carbide cement so that

[4] Registered trade name for recrystallized silicon carbide.

the passage of carbon monoxide gas into the test brick chambers could be avoided.

The high thermal conductivity of Refrax, which is practically all silicon carbide, is essential not only for transferring heat from the resistor to the test brick face of the wall, but also to maintain an even heat distribution along the entire length of the wall.

The other materials used in constructing the furnace were chosen to perform the functions best suited to them, "Infrax"[5] and porous grog being used where heat insulation is desirable, while the outer walls, partition walls, etc., were built of a good grade of fireclay refractory. The furnace is mounted on a movable steel table, is easily repaired, and takes up little room compared with the fuel-oil furnaces that it replaced.

Operation

On account of the high temperature coefficient of graphite it is necessary to have a source of variable voltage, but a variable voltage transformer is desirable for other uses in a laboratory operating different electrical furnaces and other electrical equipment. When up to temperature the furnace draws between 15 and 17 kilowatts at approximately 20 volts alternating current.

The $2^1/_2$ by $4^1/_2$-inch ends of twelve standard shape refractory brick are heated simultaneously to 1350°C and the furnace is maintained at equilibrium at that temperature before testing is begun. The temperature is measured at regular intervals by an optical pyrometer being held closely at 1350°C ± 20°. One brick from each side of the furnace is tested at the same time, the heated end being placed four inches from the 2-inch diameter orifice of a blower delivering between 28 and 30 cu. ft. of air per minute. This is the air-blast alternative spalling test of the A.S.T.M.[6] Tentative Standard for spalling for 1924. Since there are six heating chambers on each side for test brick and each brick is in the air blast for 10 minutes, they have an hour to return to temperature equilibrium between each blast. Each brick is given 20 air quenches, unless before that time it loses 20% of its original weight.

Conclusions

This furnace has been in almost continuous use during the last two years; repairs are infrequent and consist chiefly in replacing the resistor. Only the highest grade of silicon carbide and fireclay refractories can withstand 20 air quenchings without appreciable loss of weight. Silica, magnesite, and chrome refractories fail after only a few air blasts, often on the first run.

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[5] Registered trade name for heat insulating cement.

[6] Tentative Method of Test for Fireclay Brick, A.S.T.M., Tentative Standards, p. 210 (1924).

Aluminous refractories are intermediate, varying widely in resistance to spalling depending apparently on varying forms of structure, bond, etc.

The character of spalling cracks and fracture, and the shapes and sizes of spalled off pieces are so varied that it is questionable if any one theory can account for the failure by spalling due to sudden temperature changes of all types of refractories, but resistance to spalling is one of the most important properties of refractories, often determining the choice of refractory and the apparatus described is an excellent equipment for such test work.

Note Since this article was written the Acheson graphite resistor has been replaced with "Globar" brand non-metallic resistors. The general plan of the furnace is much the same, and the method of testing exactly the same as described above. These Globar resistors, which are nonmetallic resistors made of silicon carbide, have the advantage over graphite resistors in that they can be designed to carry a definite load for a fixed voltage, do not have to be protected from oxidation, and therefore last longer in service.

RESEARCH LABORATORY
CARBORUNDUM COMPANY
NIAGARA FALLS, N. Y

A NEW METHOD FOR TESTING REFRACTORY CEMENTS[1]

By Charles McMullen

ABSTRACT

A new test for refractory cements is described in which the modulus of rupture of test bars made of the cement is determined at different temperatures and plotted as a curve. The resulting curves predict the performance of cements in service. A photograph of the apparatus used is shown.

Introduction

Refractory cement, whether used for bonding refractories as a facing or for patching, or as a rammed material, is always matured in place and the method of testing that is described in this paper successfully indicates the varying physical and refractory properties of a cement as it is heated to maturity.

The testing of refractory cements in a laboratory way has always been more or less indefinite owing to the many conditions that a cement must withstand in use. The most important requirement for a satisfactory cement is that it must act as a binder between the brick or other shapes at all temperatures up to the maximum to which it will be subjected. Secondly, it should not crack on drying or firing. As a third requirement, it must be refractory enough to withstand pressure due to load at the maximum temperature encountered in use, or otherwise it is liable to run or squeeze out and cause slippage of the brickwork.

The drying qualities of a cement can be determined by cementing two bricks together on the 9- by $4^1/_2$-inch face, coating an end and a side of the pair with $^1/_8$ to $^1/_4$ inch of cement. After thorough drying in the air and then in a drier the brick may be examined for drying cracks. These same brick may be fired to a desired temperature, cooled, and examined for firing shrinkage or cracking of the cement, and also the adhering property.

A cone fusion test will give an approximate idea as to the maximum temperature at which the cement can be used. The actual temperature limit, however, cannot be determined by this method since the cone deforms only under its own weight while in the actual use of the cement it is subjected to additional pressure.

To find the strength of a refractory cement under the conditions which obtain in actual use, it must necessarily be tested while hot. For this purpose the small test furnace shown in Fig. 1 was developed and proved to be satisfactory.

The Furnace

The furnace is electrically heated with four "Globar"[2] nonmetallic re-

[1] Presented at the Annual Meeting, American Ceramic Society, Toronto, Ont., February, 1930. (Refractories Division.) Received September 9, 1929.

[2] Registered Trade Mark.

sistor heating elements, and attains a maximum temperature of 1500°C. It operates on 110 volts with a maximum power consumption of 16.5 kilowatts. While this furnace was designed particularly for testing the transverse strength of ceramic materials at various temperatures, its convenient size and ease of operation make it useful for many laboratory purposes where a uniform heat distribution is needed. Its important features include the following:

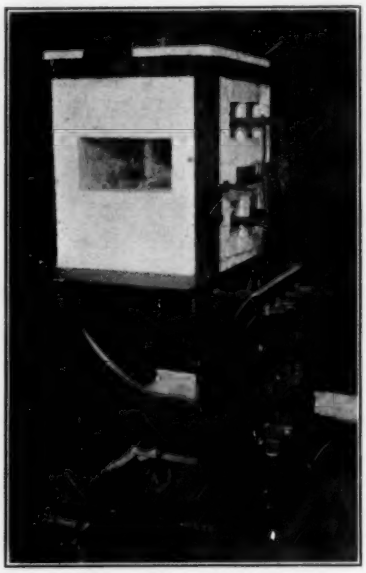

FIG. 1.

(*a*) A maximum temperature available over a long or short heating period
(*b*) Even temperature distribution throughout the 1- by 11- by 8-inch chamber
(*c*) No exhaust fumes, slag, or ashes
(*d*) Compact and movable
(*e*) Control of atmospheric conditions
(*f*) Quick replacement of heating elements
(*g*) Transverse and load-testing equipment

The Test

Test bars, 1 by 1 by 7 inches, were made by mixing dry cement with sufficient water so that the bars could be formed by pressure. These bars, after being thoroughly dried, were ready for testing. Three types of tests were made by the following process:

(1) Heating the bar to temperature and holding for four hours, then breaking (transverse) at this temperature.
(2) Same as (1) except that the bar is broken cold after having been heated to the desired temperature.
(3) Heating the bar to temperature, holding for 5 minutes, and breaking at this temperature.

Test (1) is designed to find the strength of the cement after it is in use at a certain temperature. Test (2) gives the strength of the cement when it has cooled, while (3) gives the strength on the initial firing in use.

An example of a high-grade commercial cement tested by these methods is shown in Fig. 2. Each point through which the curves are plotted represents the average of the modulus of rupture of 4 bars made of this clay bonded cement which also has an organic bond added for increased dry strength.

The immediate dip in the curves from 20 to 400°C shows the ignition of the temporary bond. The following rise to 800° can best be explained by the fact that the water of hydration leaving the clay tends to produce a tougher structure. The gradual slump in the hot strength curve from 800°C on is due to incipient vitrification in the clay which causes a weakening in its bonding power when heated. It is notable that both the cold and hot strength curves are similar up to the point where vitrification starts. This vitrification point is sharply defined by the point at which the cold strength rapidly increases.

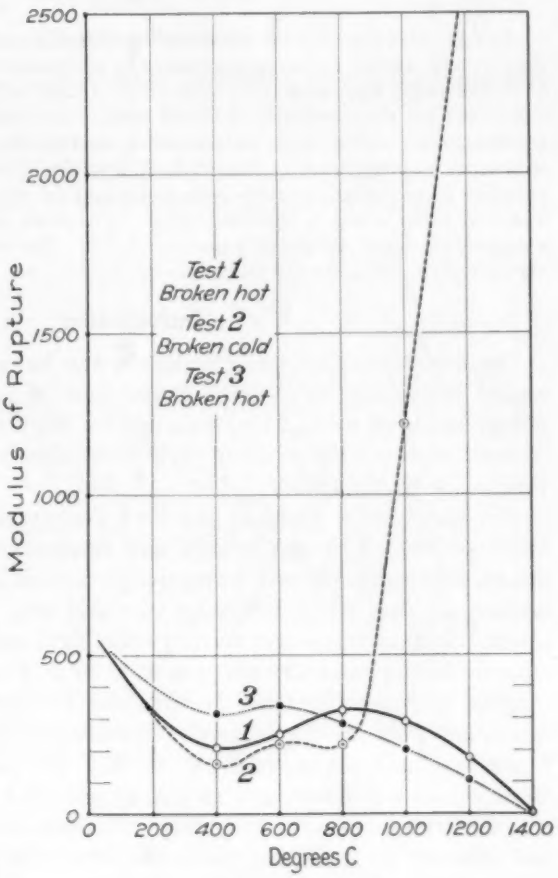

FIG. 2.

Where the curve crossed the axis of zero, modulus of rupture was taken as the ultimate temperature beyond which the cement is too weak to give a good bond between the brick while hot. Thus from the curves the strength of a cement at any desired temperature can be compared with its initial dry strength, cold strength, and also its temperature range established.

RESEARCH LABORATORY
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NIAGARA FALLS, N. Y.

GEOLOGY OF THE FIRE CLAYS OF SOUTHERN SASKATCHEWAN[1]

By G. M. Hutt

ABSTRACT

The fire clays belong to the Whitemud formation, which is of Lance (late Cretaceous) Age. The formation is usually represented by three zones: at the bottom a maximum of 45 feet of partly kaolinized feldspathic sands, a thin carbonaceous zone in the middle, and at the top a maximum of 35 feet of plastic clays intercalated with fine sands and silts. Increase of the sands in coarseness eastward implies an eastern source of the sediments, possibly the pre-Cambrian of northern Canada. The plastic clays are probably derived from the feldspathic sands and are due to a reworking of the sands and their kaolinization in Whitemud time. The strata are practically flat lying, with a regional eastward, and possibly northward, dip. The eastern clays, having fusions as high as cone 33, are more refractory than the western ones.

Introduction

The fire clays of southern Saskatchewan have been the subject of geological description by Davis,[2] Dyer,[3] and McLearn,[4] while their technology has been studied by Davis and by Worcester.[5] The present paper makes free use of the works of these authorities and also includes observations made by the author.

Fire clays are exposed in southern Saskatchewan roughly within the limits prescribed by the Alberta and International boundaries and lines drawn west and southeast, respectively, to them from Moose Jaw. These include an area about 250 miles east and west by 100 miles north and south. Within this larger territory the clays are not widespread or continuous, but apparently are confined to smaller sections of the country as Cypress Hills near Eastend, Cactus Hills, Dirt Hills near Claybank, Wood Mountain Plateau, the valleys of Twelvemile, Big Muddy and Willowbunch lakes and of Lake of the Rivers near Mitchellton, Willows, Readlyn, Verwood, and Willowbunch, as well as scattered outliers. There are certain fairly large areas, as for instance that in a direct line between Eastend and Willows, a distance of 140 miles, where the strata have been eroded

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[1] Presented at the Fall Meeting, American Refractories Institute and Refractories Division, American Ceramic Society, Columbus, Ohio, September, 1929. Received November 20, 1929.

[2] N. B. Davis, "Report on the Clay Resources of Southern Saskatchewan," Mines Branch, Canada, No. 468 (1918).

[3] W. S. Dyer, "Oil and Gas Prospects in Southern Saskatchewan," *Geol. Surv.* [Canada], No. 2127, pp. 30–38 (1927).

[4] F. H. McLearn, "Stratigraphy, Structure, and Clay Deposits of Eastend Area, Cypress Hills, Saskatchewan," *Geol. Surv.* [Canada], No. 2172, pp. 21–53 (1928).

[5] W. G. Worcester, "An Investigation of Twenty-One Saskatchewan Ball Clays," *Jour. Amer. Ceram. Soc.*, **12** [5], 360–76 (1929). Also several short reports to the Saskatchewan Government Department of Labor and Industries.

away below the level of the fire clays so that they are now absent if, as is probable, they ever existed.

The same, or similar clays are reported from Montana and North Dakota and also occur to a minor extent in Alberta.

Physical Features

Southern Saskatchewan, a part of the Great Plains topographic province, has essentially a more or less flat, base-levelled surface. The flatness is due to the nearly flat-lying character of the underlying strata and to normal base-levelling, plus the filling in of hollows by glacial drift.

Wood Mountain Plateau in the south-central part of the area and Cy-

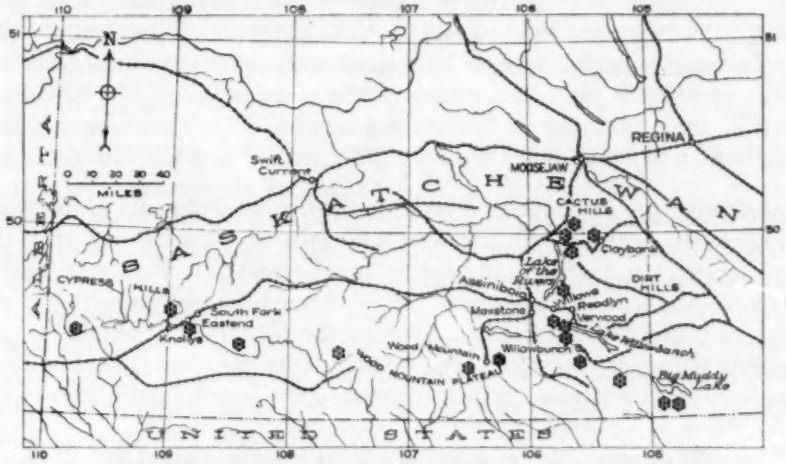

FIG. 1.—Sketch map showing principal outcrops of fire clays in Saskatchewan in relation to railway lines.

press Hills in the southwest part form the most prominent physical features. Both are plateaus built on remnants of Lance and Fort Union clays and sands, while the surrounding plains are underlain by softer, easily eroded Pierre shales. Except for the eastern edge of Wood Mountain Plateau, which is formed by Missouri Coteau, the plateaus rise gradually from the plains. Missouri Coteau is a northeastward-facing escarpment rising abruptly to heights of over 800 feet in places and in this area extending northwest from the International Boundary to a point about 15 miles west of Moose Jaw. Its features are exaggerated by glacial débris heaped over it and giving it a very ragged aspect. In some sections of Wood Mountain Plateau badland topography is pronounced.

Deep, abandoned channels of post-glacial streams form another interesting feature. Frenchman River Valley in Cypress Hills and Big Muddy

Valley in Wood Mountain Plateau are examples. Such valleys may now be occupied by much smaller streams or by long narrow lakes with intermittent drainage.

Stratigraphy

In this area Pierre marine shales, found in outcrops and in deep wells, overlie Colorado shales and Blairmore-Koctenay sandstones. The next youngest formation, the Fox Hills, consists of rusty sand or sandstone, gray when unweathered, and representing a near-shore phase of the retreating Pierre sea. The Fox Hills formation ranges in thickness from 75 feet in south-central Saskatchewan to over 100 feet in Cypress Hills.

TABLE OF FORMATIONS[5]

	Standard time divisions	Formations
Tertiary or Cretaceous	Fort Union (?)	Ravenscrag
Cretaceous	Lance	Whitemud[6]
		Estevan
	Fox Hills	Fox Hills
	Pierre	Pierre

Overlying the Fox Hills is a series of freshwater sediments formerly referred to the Fort Union. The lowest division is called Estevan after the type locality, and consists of gray to brown sands and clays with lignite. These underlie the next division, the Whitemud, at many points but are thought to be absent at Eastend, allowing the Whitemud to rest directly on the Fox Hills. Remains of Lance-age dinosaurs have been found in Estevan beds and the division is now referred to the Lance, rather than to the Fort Union as formerly.

The next division, the Whitemud, contains the important fire clays and related clays of the area. The restricted areas of outcrop of these clays have already been mentioned, exposures being along the sides of valleys or of hills, and presenting a snow-white appearance from a distance on account of the light-colored sediments making up the formation.

The sediments of the Whitemud formation are partly kaolinized feldspathic sands and silts, fire clays, and less refractory clays. In addition there are carbonaceous clays and shales and some lignite. A typical section, from Wood Mountain Plateau, is given:

Top: glacial and recent
8 feet: mauve plastic clays containing some carbon in the form of stems

[6] F. H. McLearn, "Southern Saskatchewan," *Geol. Surv.* [Canada], No. 2206, pp. 30–45 (1928). Published after this paper was presented. He now describes the occurrence of at least two distinct Whitemud zones and concludes that the Whitemuds may be early Lance, Edmonton, or intervening age. He further concludes that variations in grain size of the Whitemud sands are as much vertical as lateral and hence lateral variation cannot be used as proof of source of the Whitemuds without further study.

4 feet: white silty clay
1 foot: brown lignitic clay
8 feet: brown, carbonaceous sandy clay
11 feet: white sand containing some carbonaceous material.

This section brings out the three typical zones of the Whitemuds and their arrangement, namely, a thick zone of white sand at the base, a zone of lignite and carbonaceous sands and clays, and at the top a zone of plastic clays. There are important exceptions to this section, both in thickness and constituent materials of the zones. The carbonaceous band is usually much thinner than in this section, and is often missing, the clays grading down into sands. Quite often there is considerable sand above the carbonaceous zone, and quite often the entire thickness of the formation is made up of sands alone, although there may be thin clayey bands.

The lowest zone varies from about 45 feet to considerably less than this in thickness. It consists, in many places, entirely of partly kaolinized feldspathic sandstone, which is in the main massive but which may vary sharply in all directions in color and in amount of contained clay. These variations may show as two or three separate thick layers or as gradual changes either laterally or vertically.

The sands are pale gray to pale yellowish green to almost white in color and consist of feldspar and quartz with small amounts of mica and other accessory minerals. The feldspars include orthoclase, microcline, and soda-lime plagioclases. There is frequently a small amount of iron oxide both as grains and as stains or coatings on other minerals. Replacing the feldspar and partly filling the interstices between the sand grains is clay matter having the chemical and physical features of pure kaolin. This is present in amounts of from 25 to 55%.

The sands are fine grained but, even so, there is considerable variation in grain size. It has been pointed out by Dyer[3] and partly confirmed by McLearn and Fraser[4] that the sands increase in fineness with distance westward, a point which may have important bearing on the origin of the Whitemuds.

Thin lenses of clay are found but are not common in the sand zone. A few carbonaceous streaks and, occasionally, large concretions occur. Toward the top of the zone, when there is a carbonaceous zone above it, there is often a brownish sand containing much root matter and other plant remains.

The clays of the carbonaceous zone are usually black to brown and carry definite plant remains. They are often white firing. The lignite of this zone is never very thick, is not regular, and is not worked for itself alone.

The plastic clay zone ranges from zero to about 35 feet in thickness, and is made up of clays and silts, although there are also fine partly kaolinized feldspathic sands. The individual beds making up this zone vary markedly, both laterally and vertically, are lens-shaped and rather thin, not often

being more than a couple of feet thick. Very fine, rather irregular banding is seen in some of the clays. Plant matter is quite common. The clays range in color through white, gray, mauve, brown, and black, and are usually very plastic. Many of the clays show pronounced slickensides. There seems to be a decrease in refractoriness westward, clays in the Claybank-Willows-Willowbunch area having fusion points as high as cone 33, while Cypress Hills clays to the author's knowledge do not fuse above cone 26 and are more often semi-refractory.

In the absence of fossils from these clays McLearn has decided that on a lithological basis they are probably of Lance Age. Similar clays in North Dakota are referred to the Fort Union.

McLearn includes in the Whitemuds, for Cypress Hills area at least, a 10- to 25-foot zone of dark shales and sands which lie above the typical light-colored sediments. The reason for this is a local unconformity above this zone which indicates a short erosional interval. The dark zone itself sometimes increases in thickness at the expense of the lower zones, and may replace them laterally, even cutting down into the sand zone, a condition which implies either contemporaneous deposition or a short erosional interval prior to the deposition of the dark shales.

Overlying the Whitemud formation is the Ravenscrag, named from the type locality. It is found usually in the higher elevations of the country and has a maximum thickness of 240 feet. Its clays and sands are similar to those of the Estevan formation. The age of the Ravenscrag is not definitely known, but the basal part seems to be of Lance Age while the upper part appears to be Fort Union.

Oligocene conglomerates, shales, grits, and sandstone lie above the Ravenscrag beds in higher parts of the area in the west. Elsewhere glacial or postglacial materials overlie Ravenscrag or older sediments.

Structure

The sediments discussed in this paper are relatively flat-lying, and there are no angular unconformities. Dyer gives the following elevations of the top of the Whitemuds: at Halbrite, approximately 1900 feet; at Verwood, 2310.1 feet; near Willows, 2287.7 feet; at Eastend, approximately 3300 feet. There is thus over the whole area a regional dip to the east, between Eastend and Verwood, a distance of 150 miles, of 7 feet per mile, and between Verwood and Halbrite, a distance of 90 miles, of $4^1/_2$ feet per mile. In Eastend area there is a northerly dip, and there may also be a strong northerly dip in the eastern part of the area. There are also some small irregular folds.

There have been many small landslides at different points, caused by a slumping off of the beds into the valleys along which the clays are exposed. It seems apparent also that at least so far as the eastern part of the area is

concerned there has been some faulting. The faults extend generally in a north-south direction, and in one case at least there is a throw of 30 feet. In this faulting all beds above and including the Estevan have partaken, apparently previous to glacial time. One such fault may be observed northeast of Willows.

Especially in Cactus Hills and Dirt Hills is a peculiar secondary structure to be noted. At Claybank, near the northeast end of Dirt Hills is a group of knolls made up of great blocks of strata dipping steeply to the west, and also dipping north, while the strata in the hills themselves are practically flat-lying. Dyer discounts landsliding or slumping of a normal order and also the action of glaciers, and advances as a reason for the structure differential weathering and either the washing away of Estevan beds or their flowing because of their highly colloidal nature, hence allowing the settling of large blocks in the manner in which they are now found.

Origin of the Whitemuds

This is a problem to which McLearn particularly has paid considerable attention. The problem resolves itself into two phases: what part was played by the feldspathic sands in the origin of the fire clays, and where is the source of the sediments?

It is probable that the Whitemuds were deposited in this area as feldspathic sands, that partial kaolinization of the feldspars took place, that some of this material remains undisturbed as partly kaolinized feldspathic sands while some was re-worked, sorted, and laid down in shallow depressions on the surface in Whitemud time to form the present beds of fire clay and semi-fire clay, intercalated with silts and sands of the clay zone.

This theory of alteration in the zone of deposition, as McLearn states, demands no uplift, only normal erosion and redeposition as on any alluvial plain. No great thickness of sediment is involved. Special conditions required are at least temperate climate, some moisture, some vegetation, and a periodic lowering of the water table to promote weathering. The formation of the sand zone may have taken place rapidly, but the formation of the clay zone derived from it took a longer time to permit scour, sorting, and redeposition.

Soluble salts produced in such alteration would be carried away in solution where open drainage permitted. In closed drainage areas, however, much of the salts would remain. This might account for some of the soluble salts found particularly with some of the more plastic clays.

There may have been some kaolinization of the sands prior to their deposition. There may also have been kaolinization during the period of erosion following the Whitemud. In fact there can be little doubt that some kaolinization is still taking place. These processes, however, do not

explain various factors which are more or less satisfied by McLearn's theory.

The greatest obstacle, apparently, in the way of this theory is that it is not yet definitely known that kaolinization of the sands actually took place in Whitemud time.

It is recognized that a great part of the Cretaceous sediments of the Great Plains came from the west, as shown by their increase in coarseness westward, together with replacement of marine by delta and marginal plain conditions. Tests on several Whitemud sands, however, show an increase in coarseness eastward, which tend to show that the source of these sands is the pre-Cambrian area of northern Canada rather than the Cordilleran region. There is no reason to suppose that the Canadian pre-Cambrian could not have supplied such sediments.

This is a rather confusing point, for the sands are not markedly different from those of the underlying and overlying formations, and there is as yet no suggestion that these sediments too originated in the east.

Economic Features

The clays of the Whitemud formation are the most important in the province.

Most of the clays of value are excellently situated with respect to transportation, for the province is well served by railroads and has fair to good roads.

The clays occur in large part in outcrops which can be easily worked. Very large total reserves are indicated, but prospecting of individual deposits is necessary in view of the lens-like character of the clays and their sharp variation in character.

Actual layers of clay in the sand zone are not common, but the sands themselves contain considerable clay and are being used as clays. It is suggested that washing the sands might permit a recovery of pure kaolin for use in whiteware or refractories.

In the clay zone are most of the clay beds with some sands and silts. In general the plastic clays will be found above the carbonaceous or lignite zone, the sands or sandy clays below it.

Some of the clays and sands contain soluble salts. Iron oxide as present is quite often removable by washing or by electro-magnetic treatment.

Particularly in the vicinities of Cactus Hills, Claybank, Willows, Readlyn, Verwood and Willowbunch are the clays highly refractory, with fusion points as high as cone 33. At Claybank, the Dominion Firebrick and Clay Products Company manufactures locomotive tile and fire brick. Other clays, not now in use, as at Willows and Cactus Hills might well be investigated as materials for the manufacture of heavy-duty shapes. At Willows, the Alberta Clay Products Company operates a large pit from

which clays are drawn to Medicine Hat for the manufacture of sewer pipe and fire brick. Medalta Potteries of Medicine Hat also uses Willows clays. The International Clay Products Company of Estevan utilizes Readlyn clays for face brick, floor and wall tile, and terra cotta.

Worcester[5] has recently given an excellent paper on Saskatchewan ball clays. Most of the clays are of the ball or semi-china type. They fire from white to cream. Ball clays are being exported, from the province, in the crude unwashed state. A number of ball clays have high bonding powers, and with their high fusion points have possibilities as bond clays for the manufacture of metallurgical crucibles. Other clays are of the stoneware type.

So far as the author is aware the Cypress Hills clays are less refractory than those of the eastern part of the area. In Cypress Hills the clays are mainly of stoneware grade. A pit at Knollys, owned by the International Clay Products Company, contains clays said to compare favorably with the best foreign stoneware clay. Alberta Clay Products Company and Medalta Potteries also operate pits in this area. Some of the clays have possibilities for low-duty refractories.

Much of the water in this part of the province is alkaline. Frenchman River near Eastend is an important exception as are several small streams in Wood Mountain Plateau.

Lignite seams are common in the province and local lignite is used at Estevan as a source of fuel. Alberta coal is used by one manufacturer, while those at Medicine Hat use natural gas. There is a possibility, though apparently slight, of gas in commercial quantity being found in the Eastend area.

Department of Development
Canadian Pacific Railway
Montreal

THE INFLUENCE OF CHEMICAL COMPOSITION ON THE PHYSICAL PROPERTIES OF GLAZES*

By F. P. Hall

ABSTRACT

This paper presents some preliminary work on the study of the factors affecting the fit of ceramic bodies and glazes. From the experimental work on 118 glazes and glasses, a method is outlined for calculating from the chemical composition of the glaze, approximate values of the tensile strength, Young's modulus of elasticity, and the mean linear coefficient of expansion of the glaze in the temperature range from 25°C to the lower limit of the critical range.

Introduction‡

The elimination of crazing of glazed ware is generally conceded to be one of the most important problems of the whiteware industry. This problem has engaged the attention of the ceramic world for some time. The literature on crazing is voluminous, but generalizations are very few and leave much to be desired. This condition is probably due to the fact that sufficient fundamental data are lacking.

It is evident that there are two types of crazing, namely: (1) that which is present when the kiln is opened or which develops shortly after the ware is removed from the kiln, and (2) that which develops several months or years after the ware is in use.

The first type of crazing doubtless results from the stresses set up by unequal expansion (or contraction) of the glaze and body. The ability of a glaze to withstand these stresses is thought to depend upon its tensile strength, elasticity, thickness, and the intergrowth of crystalline material at the glaze-body contact.

The second type of crazing develops with age and is probably caused by (*a*) changes that take place in the body, such as rehydration of the body and (*b*) changes that take place in the glaze, such as the "afterworking" of the glaze. This paper deals with the factors that influence the first type of crazing of glazes.

Preparation of Samples

The composition of a glaze upon a body differs considerably from that computed from the batch composition due (1) to reaction between body and glaze, and (2) to volatilization of constituents of the glaze. For this reason it was thought advisable to study the physical properties of the unaltered glaze in the form of homogeneous glass rods and thus avoid compli-

* Publication approved by the Director of the Bureau of Standards, U. S. Department of Commerce. Received November 16, 1929. Returned to Washington for revision November 30, 1929 and received for publication on January 20, 1930.

‡ The references cited in this paper may be found on p. 198.

cating the data on glazes with that pertaining to any particular body or heat treatment of the body and glaze.

In general, the glazes used in this investigation contained a greater percentage of basic oxides than those used in the industry. This was necessary if a "plane" glass was to be obtained in a reasonable time.

The base glaze (No. 1) for series A is a lead glaze while that (No. 40) for series B is a high alkali glaze. Series C is a PbO–B_2O_5 series designed to study the effect of B_2O_3 and PbO concentrations on their constants. Series D is a group of miscellaneous glazes and glasses.

The system used in changing the composition in series A and B is that of simple addition of the oxide being investigated to the base glaze of the respective series. Thus, after adding 10% of B_2O_3 to a base glaze, the new glaze should contain 90% of the base glaze plus 10% of B_2O_3.

Melting The glazes, in batches of from 1 to 2 pounds, were melted in clay crucibles in a pot furnace and were stirred frequently with nickel or fused silica rods. They were "fined" until reasonably free from bubbles and drawn into rods with the aid of nickel or fused silica rods, depending on the temperatures of the molten glazes. From these batches rods for the physical tests were selected on the basis of uniformity of cross-sectional area and freedom from bubbles and then were annealed in an electric furnace.

Annealing In the first part of the work the rods were annealed by trial until examination in polarized light showed them to be free from strain. In the latter part of the work a satisfactory annealing temperature was determined from the thermal expansion curves.

The laboratory procedure adopted for annealing the rods was as follows: the rods were placed on a smooth refractory surface, covered with powdered diatomaceous earth and heated to the annealing temperature.† The annealing furnace was maintained at this temperature for $1^1/_2$ hours and then allowed to cool slowly.

The approximate cooling schedule was as follows: 10° the first hour, 20° the second hour, 30° the third hour, and 40° the fourth hour. In the case of glazes with a low annealing temperature, the current was turned off after four hours of controlled cooling. In the case of glazes with a high annealing temperature, the furnace was allowed to cool slowly overnight to about 200°C, after which the current was turned off. The annealing and cooling usually required about thirty hours.

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† In this work the annealing temperature used was approximately 15° above the lower critical temperature of the glaze being investigated. The lower critical temperature is here defined as that temperature at which the rate of expansion begins to increase rapidly with temperature. This point is denoted as L (No. 92) in Fig. 10. Some of the glazes gave expansion curves similar to that shown by No. 124 in Fig. 10. In the latter case the annealing temperature was taken as that corresponding to L'.

Properties Studied The physical properties of the glazes studied in this work are tensile strength, Young's modulus of elasticity, and coefficient of thermal expansion, as these were considered to be important factors in the study of glaze fit.

Chemical Analysis The procedure used in the chemical analysis of the glazes depended on the composition of the particular glaze being analyzed. The methods used for determining the common oxides (SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, and K_2O) were essentially those described for the analysis of soda-lime glass by Lundell and Knowles.[1] Zinc and lead were determined by the electrolytic methods given by Edgar F. Smith,[2] the zinc as metallic zinc and the lead as the dioxide. Boric oxide was determined by difference. This oxide was removed in the early part of the analytical procedure by several evaporations with HCl and CH_3OH. The compositions of the glazes as determined by chemical

TABLE I

GLAZE COMPOSITIONS IN PER CENT

Series A

No.	SiO_2	Al_2O_3	K_2O	Na_2O	CaO	MgO	BaO	PbO	ZnO	B_2O_3	Total
1	45.20	10.35	2.76	1.46	3.22			36.50			99.49
2	42.63	10.86	9.39	1.18	3.09			32.72			99.87
3	41.65	9.74	11.70	2.63	3.12			31.10			99.94
4	40.12	10.32	15.22	1.44	2.75			30.52			100.37
5	43.40	9.72	2.97	7.60	3.00			33.27			99.96
6	43.01	10.84	3.50	8.22	2.37			31.85			99.79
7	40.66	10.01	3.62	13.47	2.94			29.20			99.90
8	38.60	8.96	2.98	16.60	3.12			30.08			100.34
9	43.70	12.27	3.22	1.50	8.09			31.15			99.93
10	40.50	11.60	3.21	1.24	13.08			30.35			99.98
11	38.05	10.78	2.90	1.74	16.97			29.50			99.94
12	44.90	10.71	3.20	1.40	1.71	5.22		32.60			99.74
13	45.20	11.60	3.18	1.17	2.80	7.25		28.80			100.00
14	44.02	10.80	2.06	1.01	2.82		9.23	30.01			99.95
15	38.40	10.72	3.09	1.37	2.78		15.72	28.20			100.28
16	36.30	7.30	3.34	1.41	2.43		19.45	29.40			99.63
17	44.78	10.55	3.06	0.87	2.98			37.76			100.00
18	43.18	10.00	3.20	1.31	2.78			39.16			99.63
19	43.25	9.22	2.72	0.99	3.04			40.52			99.74
20	38.81	9.41	2.94	1.13	2.73			45.08			100.10
21	34.00	11.95	2.78	0.81	4.05			46.87			100.46
22	35.40	7.20	2.56	1.48	2.65			50.63			99.92
23	43.12	11.57	3.11	1.27	2.46			31.10	7.37		100.00
24	37.95	10.22	2.20	2.80	3.33			33.52	10.26		100.28
25	39.55	10.91	3.44	1.32	2.53			28.30	13.86		99.91
26	36.52	7.66	2.73	1.48	1.74			29.55	19.86		99.54
27	43.00	10.96	3.16	1.91	2.94			34.10		3.93	100.00
28	40.28	9.70	2.46	2.53	3.20			33.75		8.08	100.00
29	42.15	12.10	2.70	1.56	2.49			29.42		9.58	100.00
30	38.70	10.05	3.41	1.18	2.88			29.96		13.82	100.00
31	37.35	8.88	3.06	0.75	2.32			30.32		17.32	100.00
32	32.00	7.90	2.65	0.70	1.78			25.42		29.55	100.00
33	44.75	8.00	2.79	1.48	2.51			37.90	Mn_2O_3 2.50		99.93
34	43.10	10.05	3.09	1.42	3.21			34.30	Fe_2O_3 5.05		100.22

TABLE I (*Continued*)
GLAZE COMPOSITIONS IN PER CENT

Series B

No.	SiO_2	Al_2O_3	K_2O	Na_2O	CaO	MgO	BaO	PbO	ZnO	B_2O_3	Total
40	69.60	11.80	0.80	18.01							100.21
41	65.20	9.61	7.99	17.17							99.97
42	62.57	9.03	11.57	16.62							99.79
43	57.28	9.85	12.80	19.60							99.53
44	59.92	9.33	14.45	15.95							99.65
45	66.80	9.90	0.32	23.00							100.02
46	61.41	9.92	0.26	27.86							99.45
47	60.46	9.10	0.33	30.22							100.11
48	67.40	9.81	0.18	18.81	3.88						100.08
49	64.90	10.71		16.70	7.72						100.03
50	61.88	9.85	0.20	17.17	11.00						100.10
51	67.60	10.00	0.24	17.88	0.11	4.27					100.10
52	64.60	10.91	0.14	15.85	0.15	8.14					99.79
53	61.97	8.95	0.20	17.13	0.19	11.64					100.08
54	67.03	9.78	0.21	17.28			6.05				100.35
55	63.38	9.48	0.15	16.42			10.26				99.69
56	60.40	9.47	0.19	15.10			14.75				99.91
57	67.82	10.65	0.19	17.72				3.25			99.63
58	63.82	9.98		16.67				9.09			99.56
59	64.18	9.95	0.19	16.40				9.22			99.94
60	67,90	10.04	0.18	17.24					4.53		99.89
61	63.40	8.90	0.17	17.23					10.04		99.74
62	60.21	9.42	0.51	15.06					14.77		99.97
63	67.30	10.10	0.18	18.87						3.55	100.00
64	64.92	9.88	0.17	17.76						7.27	100.00
65	63.82	9.24	0.33	15.35						11.26	100.00
66	60.76	10.70	0.11	15.13						13.30	100.00
67	56.84	9.10	0.15	16.35						17.56	100.00
68	50.60	7.86	0.17	13.45						27.92	100.00

Series C

70	63.92	9.98		16.80				9.19			99.89
71	58.35	9.42		16.30				9.06		6.87	100.00
72	54.17	8.69	0.13	14.30				8.16		14.55	100.00
73	48.65	7.71	0.10	14.03				8.36		21.15	100.00
74	50.30	11.40	10.02	9.14				9.86		9.28	100.00
75	45.30	11.65	9.61	9.60				14.77		9.07	100.00
76	40.70	11.70	10.76	10.09				20.15		6.60	100.00
77	31.95	11.35	10.15	10.01				28.94		7.60	100.00
78	55.35	9.07	0.41	15.80				14.55		4.82	100.00
79	50.85	8.22	0.24	15.50				14.36		10.83	100.00
80	44.52	9.07	0.11	16.85				15.07		14.38	100.00

Series D

87	47.20	16.50	1.01	4.03	0.78		30.30				99.82
88	67.90	16.80	3.70	0.31	11.30						100.01
89	59.40	8.78	0.61	15.70				15.70			100.19
90	57.70	8.98	28.52	4.45							99.65
91	59.25	15.60		3.98	21.18	0.07					100.08
92	59.30	18.20		4.00		18.89					100.39
93	52.40	20.95	0.13	4.80		21.40					99.68
94	42.20	21.40		1.30	34.81	0.31					100.02
95	46.05	8.04	0.91	5.82	9.22	2.18		20.20	4.33	3.25	100.00
96	45.35	10.10	5.91	1.11	7.20	1.93		19.05	4.77	4.58	100.00
97	53.40	10.76	8.15	7.13	11.84					8.72	100.00
98	54.13	12.40	7.44	7.23		9.71				9.09	100.00
99	54.40	9.57	7.66	7.07					9.82	11.48	100.00
100	54.48	11.72	7.86	7.54			9.78			8.62	100.00
101	50.21	10.92	4.65	5.40				28.94			100.12

TABLE I (*Concluded*)
GLAZE COMPOSITIONS IN PER CENT

No.	SiO_2	Al_2O_3	K_2O	Na_2O	CaO	MgO	BaO	PbO	ZnO	B_2O_3	Total
102	37.40	4.17	7.34	1.19	3.85			45.92			99.87
103	41.45	5.81	6.14	2.44	4.17			40.02			100.03
104	35.50	10.67	5.17	7.59	8.44			12.40	2.55	17.68	100.00
105	60.00	9.05	5.65	2.40						22.90	100.00
106	81.55	2.08	0.41	4.91			As_2O_3 0.60			10.45	100.00
107	55.20	12.88	4.23	9.40		8.29				10.00	100.00
108	25.10	5.98		1.34				67.58			100.00
109	53.90	18.47	4.45	2.62	8.58			11.67			99.69
110	54.40	21.60	2.90	1.04	7.95				9.44	2.67	100.00
111	54.85	12.25	4.88	9.48					7.26	11.28	100.00
112	56.40	11.56	0.30	9.60		3.24			8.93	9.97	100.00
113	57.30	11.15	0.10	9.52		6.68			5.31	9.94	100.00
114	32.70	8.00	1.55	1.67		1.69	47.03		7.54		100.18
115	41.56	12.65	0.22	9.51		6.18		9.26	12.25	8.37	100.00
116	50.40	11.76	0.30	9.20		6.50		5.14	4.83	11.87	100.00
117	31.19	5.81	1.57	2.70	4.02			9.53	2.18	43.00	100.00
118	57.48	12.05	1.95	27.96							99.44
119	57.05	11.69	1.81	29.58							100.13
120	36.40	7.95	1.03	1.29	6.82			45.96			99.45
121	39.21	8.45	1.21	1.47	6.16			42.65			99.15
122	53.84	19.20	2.22	1.56	22.94						99.76
123	53.52	23.90	2.56	2.31	0.68	17.19					100.16
124	54.64	23.94	2.21	1.90	0.76	16.66					100.11
125	66.06	15.83	3.99	2.83	11.62						100.33
126	51.62	18.30	5.45	1.59	23.54						100.50
127	53.31	21.18	2.07	1.59	17.44	4.36					99.95
128	50.62	21.60	1.97	5.11	20.74						100.04
129	65.79	2.10	0.33	15.57	5.38	4.43			4.01	2.39	100.00
130	70.86	2.29	1.27	14.62	5.28	3.49			1.81		99.62

analyses are given in Table I. The column headed Al_2O_3 in this table represents the Al_2O_3 plus the small amounts of Fe_2O_3, P_2O_5, and TiO_2 that may have been present in the batch materials, which were of very good quality.

Tensile Strength of Glazes

Griffith[3] found that the tensile strength of small glass rods varies inversely as the diameter of the rod. For this reason it was necessary to select rods of approximately the same diameter if consistent results were to be obtained. The diameters of the specimens were determined by means of a micrometer caliper and were checked frequently by means of a cathetometer microscope. In this work, rods about 2 cm. long and 0.35 to 0.5 mm. in diameter were used for tensile strength determinations. Rods of these diameters were selected because they approach the thickness of glazes as applied in commercial use and it was easier to obtain satisfactory rods of this size.

The ends of the annealed rods were sealed into brass cups with De-Khotinsky cement. One of the cups was secured to a table by means of a small chain and the other cup was connected to a chain run over a "frictionless pulley" (as shown in Fig. 1). The load in the form of lead shot was

applied to the other end of this chain at the rate of 3500 grams per minute until rupture of the rod resulted.

Considerable care was required in sealing the rod into the cup in order that the load be applied axially and failure be produced by tension alone. The ultimate load in kilograms divided by the cross-sectional area in square millimeters gave the tensile strength in kilograms per square millimeter. From 15 to 25 rods of each glaze were broken in this manner. Values that were abnormally low were not used in calculating the average tensile strength as these values may have resulted from the rods not being axially loaded. The results obtained on from 12 to 20 of the rods were averaged and are given in Table II as the mean values of the tensile strength of the glaze. Maximum and minimum values are also given in Table II. The

TABLE II

OBSERVED AND CALCULATED VALUES FOR CERTAIN PHYSICAL PROPERTIES OF GLAZES*

Series A

	Tensile strength kg./mm.²				Modulus of elasticity kg./mm.²				Mean coefficient of linear expansion		
	Observed values			Calcd.	Observed values			Calcd.	Temp.	Ob-	Calcu-
No.	Max.	Min.	Av.	values	Max.	Min.	Av.	values	interval °C	served	culated
										× 10⁻⁶	× 10⁻⁶
1	18.8	14.0	15.6	15.3	7100	6710	6900	7050	25–530	7.4	7.2
2	18.5	16.0	17.5	16.9	6740	6510	6650	6930	24–505	8.4	8.8
3	18.9	16.2	17.7	17.6	6770	6450	6660	6820	23–540	9.5	9.7
4	19.0	16.0	18.1	18.4	6530	6410	6460	6780	26–466	10.2	10.2
5	17.8	14.6	16.0	15.6	7110	6960	7020	6950	20–440	9.5	9.2
6	18.0	14.6	16.6	15.3	7090	6950	7010	6900	24–504	9.3	9.5
7	18.4	14.6	16.4	16.1	7240	7100	7110	6870	24–355	10.8	11.2
8	19.0	11.4	15.6	16.4	7230	6930	7100	6850	24–364	13.7	12.2
9	20.9	17.1	18.1	18.1	7720	7420	7570	7540	25–671	7.3	7.7
10	26.5	18.6	20.6	21.1	8350	7820	8070	7980	20–615	7.7	8.2
11	23.8	17.8	21.0	23.5	8570	8440	8510	8450	22–673	7.8	8.6
12	20.5	17.8	18.7	17.8	7600	7520	7560	7520	24–640	6.8	6.9
13	24.9	17.7	19.5	19.5	8100	7920	7990	7940	22–595	6.9	6.7
14	15.4	12.2	14.6	16.1	7030	6700	6860	7140	26–553	7.6	7.4
15	16.5	12.0	13.0	17.7	7080	7040	7060	7200	25–635	7.3	8.0
16	13.8	10.1	13.2	13.2	7430	7120	7340	7070	22–561	8.3	8.5
17	18.4	14.0	16.7	15.4	7200	6900	7100	6980	22–540	6.8	7.2
18	19.3	13.7	15.1	15.6	6910	6820	6890	7050	22–600	7.2	7.3
19	18.0	11.4	15.0	15.7	7220	7020	7120	7060	23–470	7.2	7.2
20	17.6	14.7	15.0	16.1	7190	7010	7100	7110	22–495	7.5	7.5
21	17.7	14.0	15.0	17.2	7380	6910	7180	7380	22–580	7.7	7.5
22	16.0	12.0	13.0	16.6	7420	7110	7210	7070	23–510	7.5	7.6
23	17.8	14.3	16.2	15.3	7310	7130	7230	7290	23–560	7.5	7.4
24	17.9	14.0	15.7	16.4	7720	7290	7560	7480	24–550	7.2	8.1
25	17.8	14.8	16.7	15.6	7710	7600	7690	7480	23–615	7.6	7.8
26	17.6	13.5	15.7	15.9	7770	7450	7610	7530	24–540	7.7	8.0
27	19.0	15.3	17.6	17.4	6960	6810	6880	6930	30–580	7.1	7.1
28	20.1	16.7	18.0	19.6	6770	6380	6510	6750	22–455	7.6	7.7
29	23.4	19.1	20.1	19.6	6780	6420	6580	6700	28–555	6.7	6.7
30	23.3	19.7	22.0	22.0	6540	6510	6520	6490	23–440	6.8	6.7
31	21.2	18.9	20.0	18.0	6640	6373	6480	6280	24–454	6.0	6.4
32	19.3	12.3	18.0	18.0	6110	5790	5980	5670	23–466	6.6	5.8
33					7670	7310	7540		23–564	6.9	
34					7640	7110	7420		26–600	5.4	

TABLE II (*Continued*)

OBSERVED AND CALCULATED VALUES FOR CERTAIN PHYSICAL PROPERTIES OF GLAZES*

	Tensile strength kg./mm.²				Modulus of elasticity kg./mm.²				Mean coefficient of linear expansion		
	Observed values			Calcd.	Observed values			Calcd.	Temp.	Ob-	Calcu-
No.	Max.	Min.	Av.	values	Max.	Min.	Av.	values	interval °C	served	lated
										× 10⁻⁶	× 10⁻⁶
40	28.7	22.0	25.6	25.2	6300	6140	6240	6350	23–481	10.2	10.1
41	27.0	17.0	22.8	25.3	6100	5940	6010	6130	20–425	11.9	11.8
42	23.2	18.4	20.8	24.6	6210	5920	6030	6040	26–410	13.2	12.6
43	19.0	14.0	16.0	15.8	6280	5820	6070	6070	24–324	15.3	14.1
44	16.4	12.8	14.3	15.9	6140	5830	6010	6040	20–365	14.3	13.2
45	26.3	21.6	23.7	26.9	6490	6340	6400	6240	22–460	12.8	11.8
46	12.4	11.3	12.0	18.7	6200	5820	6000	6170	26–455	14.2	13.5
47	12.1	10.1	11.0	14.5	5990	5920	5940	6150	24–432	13.9	14.4
48	30.7	25.1	27.4	28.6	6620	6420	6550	6610	28–485	9.8	10.8
49	31.0	27.1	29.0	27.0	7200	6950	7100	6840	20–563	10.0	9.2
50	33.4	26.0	30.1	22.1	7500	7280	7380	7270	20–510	11.0	11.2
51	29.3	24.6	27.4	23.1	6880	6380	6600	6840	19–470	9.5	9.9
52	31.6	24.9	28.1	25.8	7470	7130	7330	7380	19–556	9.8	9.3
53	34.6	25.0	28.5	23.8	7530	7400	7470	7770	26–530	9.9	9.8
54	27.4	24.6	26.5	24.1	6350	6150	6270	6380	27–485	10.4	10.4
55	29.3	25.0	27.2	23.5	6410	6070	6300	6400	27–500	10.5	10.4
56	29.3	25.2	27.5	23.2	7000	6560	6770	6490	30–505	10.8	10.5
57	28.2	22.0	26.4	23.8	6380	6140	6200	6430	24–470	10.2	10.1
58	29.9	24.0	27.2	24.0	6300	6610	6480	6410	25–486	9.4	9.9
59	29.0	22.5	27.7	23.4	6660	6360	6510	6380	27–394	10.3	9.9
60	31.5	24.5	27.2	24.6	6450	6100	6270	6450	22–485	9.8	10.0
61	30.3	23.3	27.9	27.7	6650	6360	6480	6620	18–452	10.9	10.5
62	32.8	27.1	29.2	27.4	6750	6730	6740	6850	24–530	10.4	10.2
63	30.6	24.0	25.6	25.9	6860	6660	6760	6620	16–508	10.1	10.3
64	26.0	19.1	24.0	23.3	7130	6800	6940	6990	22–523	10.3	9.9
65	26.2	23.6	23.6	20.5	7330	7000	7190	7370	27–542	9.1	8.9
66	27.2	19.0	22.7	20.9	7930	7550	7740	7710	30–548	9.1	9.0
67	23.8	19.7	22.1	22.3	7330	6940	7190	7320	26–522	9.3	9.3
68	26.5	18.5	21.8	19.5	6100	5680	5920	5710	20–490	7.9	8.3
					Series C						
70	29.9	24.0	27.2	22.7	6610	6300	6480	6410	25–486	9.7	10.1
71	26.6	19.7	23.2	20.6	7530	7300	7430	7200	26–519	9.9	9.8
72	24.8	19.2	22.4	20.1	7380	7050	7200	6870	23–514	8.5	9.1
73	29.3	21.7	23.4	20.7	6100	5940	6050	6030	21–512	8.9	8.9
74	20.5	14.4	16.0	17.5	7310	6890	7080	7360	22–500	10.4	10.2
75	24.8	18.5	20.7	19.4	6860	6580	6700	6760	23–458	9.6	10.4
76	21.9	14.7	17.4	20.3	7200	6860	7090	6800	25–456	11.9	11.2
77	19.8	16.5	18.1	21.4	6750	6440	6510	6330	29–400	12.1	11.3
78	25.9	18.9	22.9	20.8	6890	6610	6780	6670	23–485	9.5	9.9
79	25.1	20.3	22.5	21.2	7250	6840	6990	6780	22–484	11.0	9.9
80	21.6	18.4	20.2	22.7	6580	6420	6480	6600	24–490	10.3	10.3
					Series D						
87	22.5	15.0	17.2	14.9	7730	7540	7660	7160	28–560	9.3	8.4
88	26.8	18.1	22.2	20.2	8050	7710	7890	7630	28–700	6.4	6.3
89	28.6	22.9	26.0	25.8	6900	6510	6640	6430	16.5–480	9.8	10.1
90	24.6	18.0	20.5	17.4	6080	5800	5980	5820	25–462	13.7	13.0
91	27.7	21.4	22.9	24.9	8700	8300	8490	8420	25–880	7.8	7.8
92	39.1	32.5	34.8	25.1	9540	9160	9360	9170	24–708	4.7	5.2
93	26.8	22.6	24.7	26.4	9900	9600	9800	9550	21–642	4.9	5.4
94	19.3	16.0	17.6	18.2	10090	9960	10060	10020	26–680	9.7	8.8
95	26.7	20.0	22.0	19.8	7630	7230	7470	7730	23–542	8.3	8.4

TABLE II (*Concluded*)

OBSERVED AND CALCULATED VALUES FOR CERTAIN PHYSICAL PROPERTIES OF GLAZES*

	Tensile strength kg./mm.²				Modulus of elasticity kg./mm.²				Mean coefficient of linear expansion		
	Observed values			Calcd.	Observed values			Calcd.	Temp.	Ob-	Calcu-
No.	Max.	Min.	Av.	values	Max.	Min.	Av.	values	interval °C	served	lated
										× 10⁻⁶	× 10⁻⁶
96	24.7	18.0	20.9	19.7	7830	7430	7600	7520	24–514	8.3	8.2
97	24.6	17.6	22.2	26.1	8340	8020	8170	8180	21–530	9.7	9.9
98	31.4	26.2	28.0	31.0	7500	7070	7290	7490	23–540	8.0	8.2
99	24.7	17.0	22.3	26.4	7230	6950	7090	6825	26–512	8.8	8.9
100	23.4	16.9	19.4	24.1	7750	7520	7660	7478			9.4
101	21.3	17.0	19.2	18.9	6550	6300	6410	6670	26–495	7.4	6.8
102	16.8	14.5	15.2	18.1	6680	6400	6580	6820	24–433	8.9	8.7
103	18.1	15.0	17.5	17.4	6830	6660	6750	6960	25–465	8.7	8.6
104	22.5	19.7	20.8	23.3	7100	6960	7020	6940	26–462	10.0	9.6
105	20.8	14.1	18.3	13.8	5430	5320	5390	5380	23–463	5.8	5.9
106	21.2	15.5	17.6	17.4	6260	6100	6170	5960	25–473	4.3	4.3
107	31.9	24.0	27.7	29.8	7310	7000	7150	7490	28–520	9.0	8.1
108	14.3	10.1	11.4	16.1	5560	5340	5440	5550	26–410	7.7	7.2
109	20.2	14.6	17.8	16.5	7730	7400	7660	7540	25–700	7.4	7.6
110	22.4	19.5	21.0	23.1	8560	8220	8380	7950	22–686	6.8	6.8
111	27.3	21.0	24.8	23.4	6900	6700	6800	6860	28–500	9.0	8.9
112	26.6	18.6	23.7	25.8	7430	7000	7210	7070	28–540	7.6	7.7
113	26.8	19.8	22.4	19.1	7360	6950	7060	7360	18–532	7.2	7.3
114	14.6	8.0	11.3	15.4	7500	7440	7530	7520	24–664	9.3	9.5
115	29.8	24.0	27.6	21.1	7400	7280	7340	7670	26–520	8.3	8.4
116	29.3	17.7	23.4	21.8	7240	6800	7000	7260	26–525	7.7	7.6
117	16.6	9.2	13.3	17.9	5980	5600	5880	5930	24–405	5.7	5.7
118	19.2	14.2	16.9	16.0	6590	6270	6390	6290	27–480	15.5	14.0
119	16.2	14.1	14.8	13.5	6730	6480	6570	6380	22–465	16.8	18.4
120	22.0	18.0	20.0	20.3	7410	7360	7400	7450	27–560	7.9	7.4
121	21.0	17.0	19.1	18.9	7460	7210	7330	7360	29–570	7.5	7.3
122	27.2	20.3	24.7	22.9	8840	8630	8730	8860	27–625	7.9	7.8
123	25.0	20.0	23.0	26.2	9590	9110	9200	9200	25–742	5.9	5.6
124				25.2	9410	9220	9330	9150	26–755	5.4	5.3
125	25.5	21.8	23.1	23.6	7780	7610	7690	7670	22–720	7.1	7.2
126	23.2	20.1	21.2	21.1	8800	8600	8670	8850	23–700	8.3	8.7
127	23.1	17.1	21.1	26.1	9160	8730	8880	8930	23–690	6.6	7.1
128	23.1	21.9	22.5	24.6	9200	8950	9070	8740	23–695	8.8	8.9
129	30.2	25.1	27.3	29.2	7330	6980	7100	7170	27–494	9.7	9.7
130				27.2	7230	6930	7040	6950	25–497	9.9	9.6

* The calculated values of the tensile strength were obtained by the use of factors given in Table III and Figs. 3 and 4; the values for the moduli of elasticity from factors given in Table IV and Figs. 8 and 9; and the values of the mean coefficients of linear expansion from factors given in Table V and Fig. 5.

fractures were examined under the microscope and those specimens giving low values showed smooth surfaces, while those giving the higher values showed a more or less furrowed surface.

Effect of Oxide Additions The effect of the addition of the various oxides on the tensile strengths of the base glazes is shown in Fig. 2. The calculated and observed values of the tensile strength are given in Table II.

The calculated values were obtained by the use of the factors given in Table III and Figs. 3 and 4. These calculated values were obtained by the

FIG. 1.—Apparatus for determining the tensile strength of glazes.

use of the equation: tensile strength = $aA + bB + cC$, etc., where a, b, c, etc., represent the percentages of the various oxides and A, B, C, etc., represent the factors for the respective oxides present in the glaze.†

The values of the tensile strength given in Table II are much higher than those given for glasses in the literature; this may possibly be the result of using rods of different dimensions, for the rods used in this investigation were much smaller than those used by other investigators.

Effect of Composition on Physical Properties

Winkelmann and Schott[4] assumed that the various physical properties of glasses were simple additive functions of the composition. Gehlhoff and Thomas[5] showed that the so-called "constants" for the oxides were not constant. They showed that the specific effect of an oxide on a glass depended on the per cent oxide present in the glass; in other words, that the "constant" for the oxide varied with the amount of that oxide in the

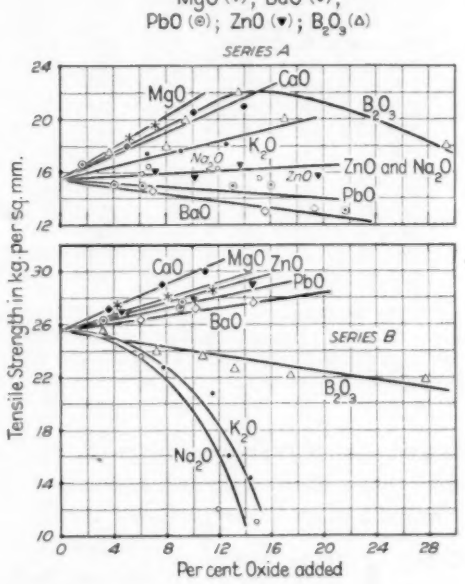

FIG. 2.—The effect of the addition of various oxides on the tensile strength of glaze No. 1 in the case of Series A, and glaze No. 40 in the case of Series B.

† This same type of equation was used in obtaining the calculated values for the modulus of elasticity and mean coefficient of linear expansion with the appropriate factors which are given in Tables IV and V. The observed values for the properties are plotted in Figs. 2, 7, and 11. These values do not always fall on a smooth curve because of experimental errors in the determinations and unavoidable variations in the composition of the glazes caused by uncontrollable volatilization of certain constituents. This is especially true of the values plotted in Fig. 11, as the alkalis have a very great effect on the coefficient of expansion.

TABLE III

FACTORS FOR TENSILE STRENGTH

The factors given in Group I should be used in all cases except those noted as follows: (1) If PbO and any or all of the following oxides are present in amounts greater than 1%, use factor given in Group II: B_2O_3, MgO, CaO, ZnO, and BaO. (2) In case PbO and B_2O_3 are present and MgO, CaO, ZnO, and BaO are absent, use factors given in Group III.

Group I

SiO_2 }	See Fig. 3	MgO	See Fig. 4	BaO	0.03	K_2O	0.40
BaO }		Al_2O_3	0.12	ZnO	0.20	PbO	0.20
Na_2O }		ZnO	0.65	SiO_2	0.07	MgO	0.80
K_2O }	See Fig. 4	B_2O_3	0.20	Al_2O_3	0.12	CaO	0.70
CaO }		PbO	See Fig. 3	Na_2O	0.20	B_2O_3	See Fig. 3

Group III

SiO_2	0.07	K_2O	0.30
Al_2O_3	0.12	PbO	0.20
Na_2O	0.75	B_2O_3	0.20

glass. The present work seems to indicate that the values of the so-called "constants" for an oxide depend not only on the amount of that oxide but also on the kind and amounts of other oxides present in the same glass. This condition necessitated the division of the factors into groups as given in Tables III and IV.

Methods of Obtaining the Factors The factors given in Tables III, IV, and V and the variations shown in Figs. 3, 4, 5, 8, and 9 were derived by inspection and trial. Thus, as is shown in Table III, the analysis of the data on tensile strength showed that there should be at least three groups of factors depending on the composition of the glaze.

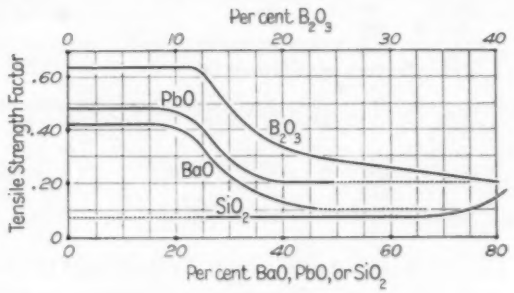

FIG. 3.—Variations in the tensile strength factors for the BaO, PbO, and SiO_2 (see Table III, Group I) for B_2O_3 (see Table III, Group II).

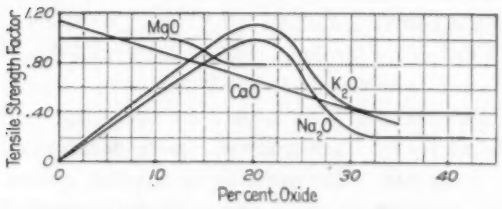

FIG. 4.—Variations in the tensile strength factors for K_2O, Na_2O, CaO, and MgO. The factors for K_2O and Na_2O depend upon the total amount of K_2O, Na_2O, CaO, and MgO present in the glaze. (See Table III, Group I.)

The simplest illustration of the method for deriving the variations of the factors is in the case of the coefficient of expansion factor for SiO_2, as shown in Fig. 5. By the use of the factors for

TABLE IV

FACTORS FOR MODULUS OF ELASTICITY

Group (*a*)

SiO_2	60	MgO	190
Al_2O_3	100	BaO	75
Na_2O	53	PbO	See Fig. 8
K_2O	43	ZnO	100
CaO	150	B_2O_3	See Fig. 8 if no PbO, MgO, or ZnO are present. If they are, see below
Fe_2O_3	100		

Group (*b*) B_2O_3 and PbO being present, but no MgO or ZnO; see Fig. 9 for B_2O_3 factor; other factors as in Group (*a*)

Group (*c*) B_2O_3 and ZnO being present but no MgO or PbO

B_2O_3	80
ZnO	100

Other factors as in Group (*a*)

Group (*d*) B_2O_3 and MgO being present but no PbO or ZnO

B_2O_3	50
MgO	190

Other factors as in Group (*a*)

Group (*e*) B_2O_3, ZnO and MgO being present but no PbO

B_2O_3	50
ZnO	100
MgO	190

Other factors as in Group (*a*)

Group (*f*) B_2O_3, ZnO, MgO, and PbO being present

B_2O_3	40
ZnO	100
MgO	190
PbO	72

Other factors as in Group (*a*)

the other oxides as given in Table V and the factor of 40×10^{-9} for SiO_2, it was found that, in the case of glazes rich in SiO_2 the calculated coefficient of expansion was greater than the observed values for this property. From an inspection of the data it also appears that as the SiO_2 content of the glaze increased the factor for SiO_2 should decrease, and the curve shown in Fig. 5 was found to satisfy the condition more nearly than a constant factor.

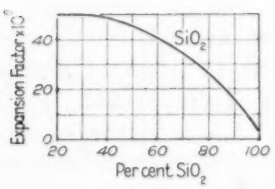

FIG. 5.—Variation of the coefficient of expansion factor for SiO_2.

The curves for BaO, MgO, K_2O, and Na_2O referred to in Group I, Table III, were adopted as they seem to most nearly fit the data, and the curves for CaO and SiO_2 were determined from factors calculated from typical glazes. The only justification for such treatment of the results is that the factors thus obtained from one set of glazes have been found applicable to other glazes of similar composition.

Modulus of Elasticity

Young's modulus of elasticity was determined on the glazes by the use

of the apparatus shown in Fig. 6, the scale on the cathetometer being calibrated by comparison with a standard scale. The modulus of elasticity was calculated by means of the formula:

$$E = \frac{Wl^3}{L12\pi r^4} \qquad (1)$$

where W = weight in kilograms
L = deflection in mm.
l = length of span in mm.
r = radius in mm.
E = modulus of elasticity in kg./mm.^{2}

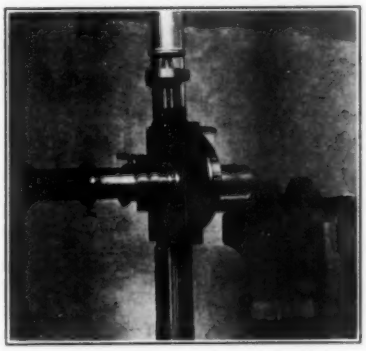

FIG. 6.—Apparatus for determining the modulus of elasticity of glazes.

The average diameters of the rods used varied from 0.8 to 3.0 mm. Ten measurements of the diameter of the rod were made with the rod in one position and these measurements were repeated with the rod rotated through 90°. The average of these twenty measurements gave the average diameter.

The rod was loaded in one position and the ratio $\frac{W}{L}$ determined; it was then rotated through an angle of 90°, loaded, and the ratio $\frac{W}{L}$ determined for this position. Generally ten loadings were made for each position. The average values of $\frac{W}{L}$ and r were used in formula (1) for determining the modulus of elasticity. Four rods were tested in this manner.

The length of the span used in this work varied from 4 to 6 cm., depending on the diameter of the rod being tested. The maximum deflection obtained in the various measurements was one and one-half diameters.

The effect of the addition of various oxides to the two-base

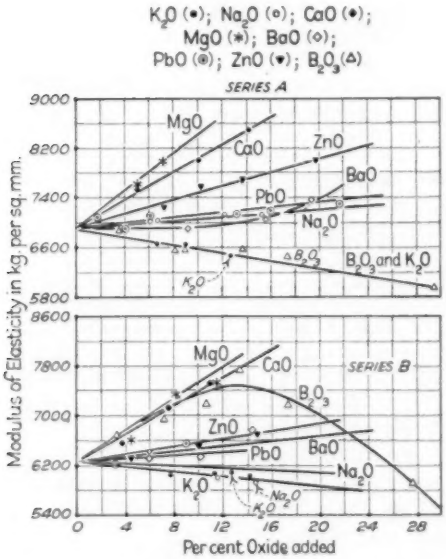

FIG. 7.—The effect of the addition of various oxides on the modulus of elasticity of Glaze 1 in the case of Series A and Glaze 40 in the case of Series B.

glazes on the modulus of elasticity is shown in Fig. 7. Table II gives the observed values and also the calculated values, which were determined by the use of both the factors given in Table IV and the variations shown in Figs. 8 and 9.

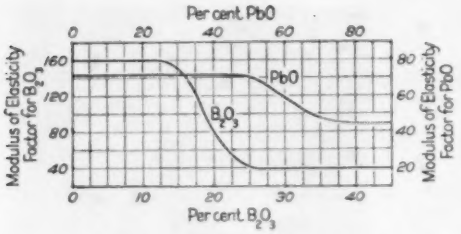

FIG. 8.—Variations of the modulus of elasticity factors for PbO and B_2O_3. (See Table IV, Group *a*.)

It will be noted that in the case of Series B, B_2O_3 gives a maximum in the curve. This result confirms the work of Gehlhoff and Thomas.[5] In the case of Series A, which is a lead glaze, the effect of B_2O_3 is a straight-line function of the composition. This and similar conditions necessitate the division of the factors for the oxides as given in Table IV. Table VI gives the results

TABLE V

FACTORS FOR AVERAGE COEFFICIENT OF LINEAR EXPANSION OVER RANGE FROM ROOM TEMPERATURE TO LOWER CRITICAL TEMPERATURE

Na_2O	380×10^{-9}	PbO	75×10^{-9}
K_2O	300 "	Al_2O_3	50 "
CaO	150 "	SiO_2	Variable (see Fig. 5)
BaO	120 "	B_2O_3	20×10^{-9}
ZnO	100 "	MgO	20 "

of the use of these factors for calculating the values of modulus of elasticity of some soda-lime glasses. The observed values are those of Clarke and Turner.[6]

The observed values given by Rieke and Steger[10] cannot be computed from the factors developed in the work on which the present paper is based nor by the factors given by Winkelmann and Schott.[4] The values given by Rieke and Steger seem to be consistently lower than those obtained by other investigators.

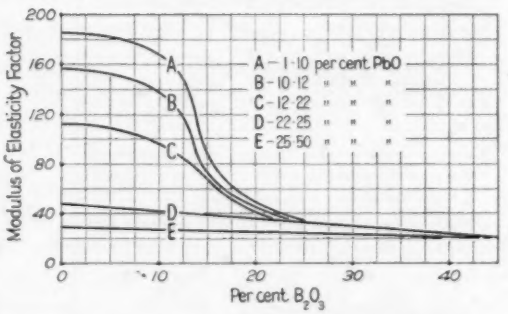

FIG. 9.—Variation of the modulus of elasticity factor for B_2O_3 with the PbO and B_2O_3 content of the glaze. (See Table IV, Group *b*.)

Mean Coefficient of Linear Expansion

The Fizeau-Pulfrich method, which has been used for a number of years at the Bureau of Standards for the measurement of small dilatations, was

used in this work for the determination of the thermal expansion of the glazes. This method is described in several Bureau of Standards publications.[7,8]

The samples used were rods, and the furnace was heated at an approximately uniform rate of 3°C per minute. The results given are for the coefficient of expansion of the rods in a direction at right angles to the longitudinal axis of the rod. All of the coefficients given in this work were obtained on the second heating because the first heating served chiefly to anneal any rods that had not been properly annealed.

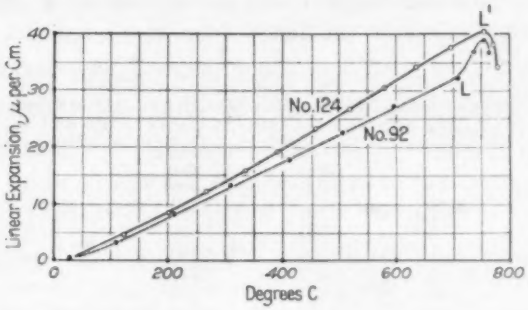

FIG. 10.—Typical expansion curves for glazes.

Examples of expansion curves are shown in Fig. 10. The curve over the range 25 to 125°C usually shows a very slight increase in rate of expansion as the temperature increases. From about 125°C to the lower critical temperature, the expansion is practically a straight-line function of the temperature. From the lower critical temperature to the upper critical temperature the rate of expansion increases very rapidly with temperature and above the upper critical temperature the glaze begins to soften.

The expansion of a glaze over the range 20°C to the lower critical temperature is, strictly speaking, a function of both temperature and composition, but for the present work it was considered sufficient to use the mean coefficient over this temperature range and express the effect of the various oxides as

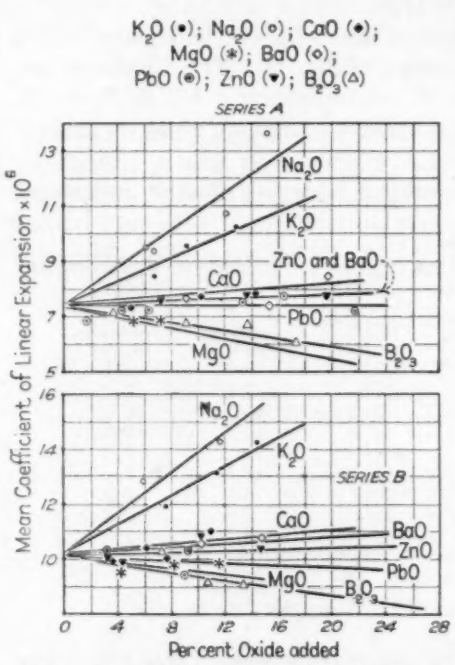

FIG. 11.—The effect of the addition of various oxides on the coefficient of linear expansion of Glaze 1 in case of Series A and Glaze 40 in the case of Series B.

constants depending on composition only, rather than attempting to develop more complex expressions involving temperature also.

The coefficients of expansion reported in this paper are the mean coefficients over the range from room temperature to the lower critical

TABLE VI

VALUES OF YOUNG'S MODULUS OF ELASTICITY FOR SODA-LIME GLASSES AS DETERMINED BY CLARKE AND TURNER[6] AND AS CALCULATED BY USE OF FACTORS GIVEN IN TABLE IV

No.	Determined value (kg./mm.²)	Calculated value (kg./mm.²)	No.	Determined value (kg./mm.²)	Calculated value (kg./mm.²)
1	5784	5860	7	6804	6630
2	5930	5960	8	6965	6670
3	6175	6090	9	7034	6790
4	6333	6540	10	7249	6920
5	6426	6290	11	6912	7040
6	6700	6510	16	8343	7720

temperature. The correction for the change in index of refraction of the air with temperature was made according to the formula given by Peters and Cragoe.[8]

The values of the coefficients of expansion of the glazes for the indicated temperature range are given in Table II.

The effect of the addition of various oxides to the two base glazes on the average coefficient of expansion is shown in Fig. 11. The calculated and observed values of the coefficients of expansion are given in Table II. The factors used in computing the calculated values are given in Table V and Fig. 5.

The observed values of the coefficients of expansion of some commercial

TABLE VII

COEFFICIENT OF LINEAR EXPANSION OF SOME GLASSES AS DETERMINED BY PETERS AND CRAGOE[8] AND AS CALCULATED FROM THE CONSTANTS GIVEN IN TABLE V

No.**	Determined coefficient $\times 10^{-6}$	Calculated coefficient $\times 10^{-6}$	No.**	Determined coefficient $\times 10^{-6}$	Calculated coefficient $\times 10^{-6}$
1–2	8.8	8.4	13	8.8	7.9
3	9.9	9.4	14	7.0	7.4
4	10.8	10.2	15	10.4	10.0
5	10.1	9.5	16	10.7	9.9
6	9.9	9.5	17	10.3	9.9
7	9.4	8.7	18–19	10.2	9.7
8	10.4	10.1	20	6.9	7.5
9	10.2	9.8	21	3.6	4.3
10	9.0	9.2	22	5.6	7.0
11	9.0	9.2	31–32	6.4	7.2
12	9.7	8.6			

** Numbers are those used in Bur. Stand., *Sci. Paper*, No. 393.

glasses as determined by Peters and Cragoe[8] are given in Table VII. The calculated values given in this table were obtained by use of the factors given in Table V and Fig. 5. The work of Winkelmann and Schott[4] and English and Turner[9] on the expansion of glasses covers the temperature

range 20 to 100°C and the values thus obtained cannot be compared with the results obtained in the work of Peters and Cragoe[8] or in the present work which covers the range from 25°C to the lower critical temperatures of the glasses.

Example of Computation

As an example of the method of computing the tensile strength, modulus of elasticity, and mean coefficient of linear expansion, consider glaze No. 48.

(*a*) Tensile strength. See Table III. Since this glaze does not contain PbO, the factors will be found in Group I of Table III and the figures referred to therein.

(*b*) Modulus of elasticity. See Table IV. Since B_2O_3, PbO, MgO, and ZnO are absent, take the factors from Group (*a*) of Table IV.

(*c*) Mean coefficient of linear expansion. See Table V for factors.

TENSILE STRENGTH

Composition		Factors	Computed value
SiO_2	67.40%	0.075 (from Fig. 3)	$67.40 \times 0.075 = 5.05$
Al_2O_3	9.81	0.12 (from Table V)	$9.81 \times 0.12 = 1.17$
K_2O	0.18	1.08	$0.18 \times 1.08 = 0.19$
Na_2O	18.81	0.96 (from Fig. 4)	$18.81 \times 0.96 = 18.06$
CaO	3.88	1.07	$3.88 \times 1.07 = 4.15$
		Total	$= 28.62$ kg./mm.^{2}

The factors 1.08 and 0.96 used above for K_2O and Na_2O, respectively, are obtained from the K_2O and Na_2O curves in Fig. 4 by projection from the point 22.21%, because 22.21% is the sum of the percentages of K_2O, Na_2O, CaO, and MgO. But the factors so obtained must be multiplied by the actual percentage of K_2O and Na_2O present.

MODULUS OF ELASTICITY

Factors		Computed value
60		$67.40 \times 60 = 4044$
100		$9.81 \times 100 = 981$
43	(from Table IV)	$0.18 \times 43 = 8$
53		$18.81 \times 53 = 998$
150		$3.88 \times 150 = 582$
		6613 kg./mm.^{2}

MEAN COEFFICIENT OF LINEAR EXPANSION

Factors		Computed values
37×10^{-9}	(from Fig. 5)	$67.40 \times 37 \times 10^{-9} = 2494 \times 10^{-9}$
50×10^{-9}		$9.81 \times 50 \times 10^{-9} = 490 \times 10^{-9}$
300×10^{-9}		$0.18 \times 300 \times 10^{-9} = 54 \times 10^{-9}$
380×10^{-9}	(from Table V)	$18.81 \times 380 \times 10^{-9} = 7150 \times 10^{-9}$
150×10^{-9}		$3.88 \times 150 \times 10^{-9} = 582 \times 10^{-9}$
		$10{,}770 \times 10^{-9}$
		or 10.77×10^{-6}

Conclusions

The factors for the glass-forming oxides derived from the physical tests reported in this paper will enable one to estimate the tensile strength, Young's modulus of elasticity, and coefficient of linear expansion of a glaze from its chemical composition, if the composition does not vary too greatly from those considered in this report. It is planned to study the effect of the three properties, elasticity, tensile strength, and thermal expansion of the glaze on the fit of glaze and body.

The writer wishes to acknowledge the assistance of E. J. Vachuska for his work in determining the thermal expansion of the glazes.

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A QUICK METHOD OF DETERMINING THE WATER CONTENT OF CLAYS[1]

By C. L. Deeds

ABSTRACT

The water content of clay is determined by taking a representative sample of the material, weighing out 2 kg. of it and adding 4 kg. of water. The sample is blunged quickly. A 250-cc. flask is filled with the resulting slip and weighed. The amount of dry clay is determined from the relation:

$$D = (P-250)(G/G-1)$$

where D = weight of dry clay
P = weight of slip
G = specific gravity of dry clay.

From this the per cent water in the moist clay is readily computed.

Introduction

Where it is necessary to make frequent moisture determinations and especially where the ball soak is omitted, being replaced by the use of shredded ball clay from the bin, it is important that frequent determinations be made. It is equally essential that they be made quickly since the water content must be known before a car is unloaded. It takes considerable time to dry a clay sample of any size and the results are erratic if the temperature of 110°C is exceeded. To cope with this situation the following method has been adopted for determining the moisture content of clay and it is found to be correct within 1% which is fully within the requirements of the slip house.

Procedure

Preparation of Sample A representative sample of about 10 kg. is taken by digging down into the clay to the depth of about one foot. From this a sample of 2 kg. is weighed out and 4 liters of water added.

Obtaining Data and Calculations

By means of a high-speed blunger this mixture is reduced to a slip in a few minutes. A 250-cc. flask is filled with this slip and weighed. With the aid of the following formula the content of the dry clay is readily computed.

$$D = (P-250)(G/G-1)$$

where D = weight of dry clay in grams
P = weight of 250 cc. of slip
G = specific gravity of dry clay (ball clay is 2.449).

From the total weight of the slip, the weight of 250 cc. of slip and the weight

[1] Presented at the Annual Meeting, American Ceramic Society, Toronto, Ont., February, 1930. (Heavy Clay Products Division.) Received December 16, 1929.

of dry clay in 250 cc. which are known, the weight of dry material in the 6000-gram batch is calculated by the relation:

$$P/D = 6000/X.$$

Again the per cent of water contained on the moist clay is computed as follows:

$$\text{Per cent water } \frac{2000 - X}{2000} \times 100 \text{ or } 100 - X/20.$$

Accuracy of Data Checking the water content thus determined against the method of drying at 110°C, the following results have been obtained for the water content of different ball clay samples:

Slip method (%)	24.85	26.85	24.95	26.06	26.57	28.50
Dried at 110°C (%)	25.70	27.10	24.30	26.33	27.20	28.50

Specific Gravity of Clay Substituting these water content values in the formula given above and solving for the specific gravity of the dry clay itself this was found to average 2.499. This differs from the specific gravity of the clay as determined by means of the pycnometer which was found to be 2.534. For our purpose it was, therefore, necessary to employ the lower specific gravity value of the clay and it is recommended that the density of the dry clay required for similar work be determined not by the pycnometer but by finding the water content of of the clay at 110°C and substituting it in the calculation. This is desirable also for the reason that a larger sample can be used in place of the small amount required by the pycnometer determination. The discrepancy is apparently due to the slip manipulation, the varying amount of carbonaceous material, the amount of air in the slip, and other factors.

HOMER LAUGHLIN CHINA CO.
NEWELL, W. VA.

AN INVESTIGATION OF THE POSSIBLE USE OF CERTAIN CALIFORNIA CLAYS IN VITREOUS CHINA SANITARY-WARE BODIES[1]

By W. F. Dietrich[2] and W. W. Meyer[3]

ABSTRACT

A bonding clay from Riverside County, a plastic fire clay from Placer County, and a washed, white-firing clay from Amador County, were tried in vitreous china sanitary-ware bodies. Descriptions and properties of the clays are given. Twenty trial bodies were tested. The bonding clay and the plastic fire clay were found unsatisfactory for use in this class of ware.

Based on laboratory tests, the use of the washed clay from Amador County, to the extent of 10 to 30% of the body mixture, is quite feasible. This would reduce the total production cost of ware manufactured in California plants by 1.0 to 2.5%, depending upon the location of the consumer and the proportion of local clay that can be utilized. A body containing 30% of the washed California clay and no English china clay proved to be as good as the standard type body used for comparison; while another mixture, containing 18% of the washed clay, was superior in many respects to the standard body. The effects of additions of ground biscuit, magnesium and calcium carbonates, and sodium chloride, were also determined.

Subsequent commercial tests in a whiteware plant showed that under the conditions prevailing in that plant, from 10 to 15% of the California clay was the maximum that could be used without increasing the vitrification temperature of the body. In this case, the California clay displaced a mixture of china clay and ball clay, rather than the china clay alone. It was also necessary to alter slightly the silica-feldspar ratio.

Introduction

California sanitary-ware plants import practically all of the constituent clays from England and from the eastern portion of the United States at a considerable freight charge. Sporadic attempts have been made in the past to utilize California clays in sanitary-ware bodies. Some use has been made of china ball clays from the Hart Mountains,[4] but a long truck and rail haul to market, and the fact that some of these clays have a tendency to bloat at vitrification temperatures, has mitigated against their more general use.

From time to time, clay-washing experiments have been conducted in the Ione district of Amador County, but have failed through various causes

[1] Excerpts from a thesis submitted by W. W. Meyer to the Dept. of Mining Engineering of Stanford University in partial fulfilment of the requirements for the degree of Ceramic Engineer. The thesis was prepared under the direction of W. F. Dietrich. In the preparation of this article, certain details, not embodied in the thesis, were added by both authors; and the results of subsequent commercial tests, carried out by Mr. Meyer, are also included in the paper.

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[3] Ceramic Engineer, San Francisco, Calif.

[4] W. F. Dietrich, "Clay Resources and Ceramic Industry of California," Calif. Div. of Mines and Mining, *Bull.*, No. 99, pp. 103–104 and 106–108 (1928).

to establish commercially successful operations. Part of this failure has been due to the washed sand, not having an industrial value. In other cases, an inadequate washing plant, combined with a lack of appreciation of the needs of the pottery trade, have caused failures.

Clay producers do not always realize that the successful use of a new raw material in a ceramic plant usually involves a series of costly experiments, which are justified only if the prospective savings from the substitution are sufficient to return the cost of the experimental work within a comparatively short period, and an additional return commensurate with the risk incident to substituting a new material. To secure business a clay producer must demonstrate the value of his clay for specific purposes, and show evidence that he can deliver clay uniform in quality for a period of years.

A clay-washing plant on one of the Ione properties has been started and has a good chance of success. Plans are being considered for the construction of a modern washing plant on the Carlisle deposit[5] to produce for the clay-working, the calsomine, and the paper industries. The studies here reported concern chiefly the suitability of the Ione clay for the whiteware industries.

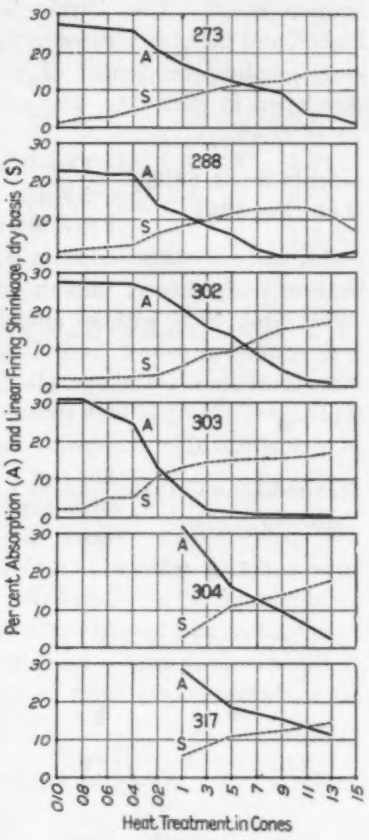

FIG. 1.

Standard Body and Raw Materials

Standard Body The type of sanitary-ware body used as a comparator in all of the laboratory work is composed of 32.5% "M. C. P." English china clay, 7.5% "Black N" English ball clay, 10% No. 11 Tennessee ball clay, 25% Campo (San Diego County, Calif.) feldspar, and 25% silica. This body was obtained after several trial mixes, and was found to be very good in every respect. It has a fair dry strength, is easily deflocculated, is well vitrified at cone 10, does not blister when fired to cone 12, and fires to a good white color.

Raw Materials Various proportions of three different California clays were substituted into this body. A brief description

[5] W. F. Dietrich, *op. cit.*, p. 57.

of the California clays is given below. Table I gives the chemical analyses of all of the raw materials used, Fig. 1 shows the fired shrinkage and absorption data for the various clays used, and Table II gives certain other data on their ceramic properties.

Alberhill "SH-4" ball clay (Lab. No. 273) This clay may be classed as a ball clay on account of its smooth and strong plasticity, good bonding strength, nearly white-fired color, and good vitrification range. The vitrification temperature, however, is somewhat higher, and the plastic deformation before rupture somewhat less, than the corresponding properties of a standard ball clay. Steel hardness is developed at cone 02. The total linear shrinkage, plastic basis, at cone 15, is 22.4%.

Lincoln No. 1-6 Clay (Lab. No. 288) This is a plastic fire clay, typical of the Lincoln district. It is widely used in the manufacture of fire brick, stoneware, pottery, faience tile, terra cotta, and for other purposes where its long vitrification range, low vitrification temperature, smooth and strong plasticity, and ability to withstand rapid firing without cracking are of especial value. Steel hardness is developed at cone 1, and vitrification is complete at cone 9. The maximum total linear shrinkage, plastic basis, is 21.5% at cone 11. The fact that it produces a body of high shrinkage and light buff color makes it unsuitable as a constituent of whiteware bodies.

Washed Ione Clay (Lab. No. 317) The raw clay contains approximately 50% of +200-mesh sand, which is removed by washing in a long series of wooden troughs. The clay is settled in large tanks, de-watered in a plate and frame filter press, dried, and sacked for shipment. The washed clay has smooth but weak plasticity, deflocculates readily, and fires to a white color comparable with that of a good grade of English china clay. Steel hardness is developed at cone 9. The total linear shrinkage, dry basis, is 22.2% at cone 9, and 24.5% at cone 13.

TABLE I

CHEMICAL ANALYSES OF RAW MATERIALS USED

No. sample	273 California ball	277 Campo feldspar	288 Plastic fire clay	302 Tennessee ball	303 English ball	304 English china	317 California washed clay
	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Ignition loss	18.9	0.7	10.3	11.6	14.4	12.5	12.3
SiO_2	38.0	61.0	52.5	49.1	44.8	45.3	49.7
Al_2O_3	42.0	20.9	33.5	38.0	38.2	41.0	35.2
Fe_2O_3	0.5	0.4	2.5				0.9
CaO	0.7	0.1	0.8	0.3	0.5	0.2	0.3
MgO	0.1	0.3	0.6			0.4	0.8
TiO_2							1.3
Na_2O	0.1	6.4	0.2	1.3	1.6	0.4	0.3
K_2O		10.9	0.6	0.2	0.2	0.6	0.2
Total	100.3	100.7	101.0	100.5	99.7	100.4	101.0

Particle Size Analyses Particle size analyses of six of the raw materials were made according to the method described by Scripture and Schramm.[6] These determinations were made after it was found that clays Nos. 273 and 288 were not adapted to use in cast

TABLE II

SUMMARIZED CERAMIC DATA ON CLAYS USED

Clay no.	Designation	% S.W.	% P.W.	% W.P.	D.T.S.	% L.D.S.	Softening pt. in cones	% + 200-mesh
273	Alberhill SH-4	15.6	21.9	37.5	249	7.9	34	4.6
288	Lincoln 1–6	19.7	19.1	38.8	239	10.3	31–32	0.6
302	Tenn. number 11 ball	22.9	23.1	46.0	275	11.1	33–34	<0.1
303	English Black N ball	27.5	23.9	51.4	350*	11.3	33–34	3.0†
304	English China (M. C. P.)	13.5	28.8	42.3	50*	6.4	34–35	0.2
317	Amador washed	22.6	29.2	51.8	200*	10.1	34	0.3

* Approximate.

† Mainly carbonaceous matter.

% S.W. (shrinkage water); % P.W. (pore water); % W.P. (water of plasticity); D.T.S. (dry transverse strength); and % L.D.S. (linear drying shrinkage, % dry length).

whiteware bodies, so these were not analyzed. The results are given in Table III.

TABLE III

PERCENTAGE DISTRIBUTION OF PARTICLE SIZES IN RAW MATERIALS

No. sample	305 Silica	277 Campo feldspar	302 Tennessee ball clay	303 English ball clay	304 English china clay	317 California washed clay
>74.0μ diam.	3	4		3*		<1
74.0–52.3μ	6	15	<1	5	<1	<1
52.3–37.0	9	16	<1	5	1	<1
37.0–26.2	7	9	1	5	3	2
26.2–18.5	7	3	1	3	3	4
18.5–13.1	5	3	2	2	5	6
13.1–9.25	10	2	2	3	8	6
9.25–6.54	15	4	4	5	6	7
<6.54μ diam.	38†	44	90	69	74	74

* A large part of this is particles of coal.

† These percentages are obtained by difference.

Note In the work of Scripture and Schramm, the value of K in the equation $V = KD^2$ was taken as 885, but in view of their results of particle sizes obtained by sedimentation compared with their microscopic measurements, and the work of Liddell[7] and Richards,[8] a value for K of 700 was used in this work. Considering the results obtained by the above workers, it was not deemed advisable to attempt a classification by this method of the particles less than 6.54 microns in diameter, as below this size

[6] *Jour. Amer. Ceram. Soc.*, **8** [4], 243 (1925).

[7] Liddell, "Handbook of Non-Ferrous Metallurgy," Vol. I, p. 135.

[8] Taggart, "Handbook of Ore Dressing," p. 552.

Stokes' law is not a very good approximation of the settling velocity of quartz or clay particles.

The limit of accuracy of this method is about 1%, due to the difficulty in reading the liquid levels in the tubes, the errors involved in weighing, those due to the eddying of the pulp in the settling tubes when first filled, and again when syphoned, and possible errors in drafting the results.

The fact that such a large proportion of each clay was below the particle size limit of this classification makes it difficult to predict their ceramic properties from the results obtained.

Experimental Bodies

The molecular formulas of the standard body and raw materials and the approximate equivalent weights are shown in Table IV.

TABLE IV

MOLECULAR FORMULAS OF STANDARD BODY S, AND RAW MATERIALS

	(No.)	R_2O_3	RO_2	RO	Equivalent wt.
Body S		1.00	4.26	0.29	
Clay	273	1.00	1.53	0.04	242
"	288	1.00	2.54	0.11	294
"	302	1.00	2.20	0.08	270
"	303	1.00	2.00	0.10	266
"	304	1.00	1.88	0.07	250
"	317	1.00	2.41	0.11	288
Feldspar	277	1.00	4.88	1.10	485
Silica	305		1.00		60

A list of the body compositions tried are given in the order in which they were tested in Table V. Care was taken to keep outside of the boundary of craze area, given by Purdy and Potts.[9] The clay content of the bodies, with the exception of B-1 and B-2, was never higher than 50% and the feldspar was maintained below 30%.

Bodies A-1, A-2, B-1, and B-2 were calculated to the same molecular formula as body S, but the remainder of the compositions were arrived at by substitution and observation of the results of previous mixtures. The molecular formula of none of the bodies is very different from that of body S; *e.g.*, body E-3 has the formula 1.00 R_2O_3, 4.49 RO_2, 0.34 RO.

Preparation of Slip

A two-kilogram batch of each body was prepared. The clays were added to about 600 cc. of water in a one-gallon glazed, stoneware crock, and allowed to soak overnight. The deflocculating agents (sodium silicate and sodium carbonate[10]) were next added and the mixture stirred until no lumps of clay existed.

[9] *Trans. Amer. Ceram. Soc.*, **13**, 451 (1911).

[10] The sodium silicate solution was prepared by diluting a 40° solution, containing the silicate of the formula $Na_2Si_4O_9$, to a concentration of one gram of the dry silicate in 10 cc. of solution. The sodium carbonate solution was made by dissolving dry Na_2CO_3 in water to give a concentration of one gram per 10 cc. of solution.

It was found that nearly all of the slips were made most fluid with the addition of 0.10% (20 cc.) of sodium carbonate, and 0.25% (50 cc.) of sodium silicate. These percentages were used throughout, except in the standard body S, which required 0.05% less of the sodium silicate.

In each preparation, 0.005% of cobalt carbonate[11] was added to the fluid mixture of clay and water.

After adding the stain, the feldspar and silica were added in small portions and stirred in. The ground biscuit, magnesium carbonate, calcium carbonate, and sodium chloride were added to those slips containing them

TABLE V

BATCH FORMULAS OF BODIES TESTED

No. body	305 Silica	277 Campo feldspar	302 Tennessee ball clay	303 English ball clay	304 English china clay	317 California washed clay	273 California ball clay	288 California plastic fire clay
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
S	25.0	25.0	10.0	7.5	32.5			
A-1	22.5	27.5				26.0	24.0	
A-2	24.5	24.7				27.3	23.5	
B-1	20.2	21.0				28.8		30.0
B-2	23.5	24.0				28.0	17.5	7.0
C-1	25.0	25.0				25.0	25.0	
C-2	25.0	30.0				22.5	22.5	
C-3	20.0	30.0				25.0	25.0	
C-4	25.0	25.0				20.0	30.0	
D-1	25.0	25.0		7.5		32.5	10.0	
D-2	25.0	25.0	10.0			32.5	7.5	
E-1	25.0	25.0	10.0	7.5		32.5		
E-2	25.0	25.0		15.0		35.0		
E-3	22.5	27.5	10.0	10.0		30.0		
E-4	22.5	27.5	5.0	15.0		30.0		
F-1	22.5	27.5	5.0	15.0		30.0		
	+4.0%—150-mesh, biscuited E-4							
F-2	22.5	27.5	5.0	15.0		30.0		
	+0.4% $CaCO_3$ and 0.6% $MgCO_3$							
F-3	22.5	27.5	5.0	15.0		30.0		
	+0.8% $CaCO_3$ and 1.2% $MgCO_3$							
F-4	22.5	27.5	5.0			30.0		
	+0.25% NaCl and 1.5%—150-mesh, biscuited E-4							
G-1	23.5	26.5	7.0	12.0	13.0	18.0		

at this time. It was sometimes necessary to increase the amount of water slightly to obtain workability. After stirring until smooth the slip was screened through a 100-mesh 12-inch copper screen, with the aid of a brush, and placed again in the crock. The following morning the mixture

[11] A. S. Watts, "Note on Cobalt Stain in White Ware Bodies," *Jour. Amer. Ceram. Soc.*, **4**, 451 (1921). The cobalt carbonate stain was prepared by dissolving separately 100 grams of crystalline cobalt sulphate ($CoSO_4 \cdot 7H_2O$) in 200 cc. of hot water, 40 grams of sodium carbonate in 600 cc. of hot water, and mixing the two together. This stain was then diluted (103 cc. of this stain and 397 of water) to give a suspension of one gram of cobalt carbonate per 100 cc.

was put into a half-gallon glass churn and agitated for about fifteen minutes. The density and viscosity were then taken.[12]

A large supply of body E-4, for use in the F series, was made by mixing a thin slip of the constituents in a mechanical blunger and filter-pressing it, after which the cakes were dried, broken up, and used as needed.

Casting of Test Bars Test bars were cast 8.05 by 1.16 by 0.62 inches, three at a time, in plaster molds. In from thirty minutes to an hour the bars were solid but were not removed from the mold until the slip reservoir at the top of the mold was solid. On removal from the mold, the bars were dried in air for three days in a drying oven at 75°C for several hours, and at 110°C overnight. They were then cooled in desiccator jars, where they were kept until tested.

Testing Procedure

Drying shrinkage and dry transverse strength determinations were made on all bodies. The broken bars from the dry transverse strength determinations were smoothed on the ends and fired for obtaining firing shrinkage and porosity. Two test pieces ($^1/_2$ by 1 by 2 inches) of each body were fired at each of three temperatures between cones 9 and 12, in a Denver Fire Clay Company, oil-fired, assay-muffle furnace. Two test pieces of several of the bodies were fired in the biscuit tunnel kiln of a local sanitary ware plant. The laboratory firing schedule was 11 hours to cone 12, compared to about 36 hours to cone 10, in the tunnel kiln, so that cone 11 in the laboratory firing gave results comparable to cone 10 in the commercial firing. Fired transverse strength at cone 11 (in the laboratory) was obtained on the five best bodies and on the standard.

Final tests were made on the five best trial bodies and on the standard, and on a glazed sample piece from a local sanitary ware plant for glaze fit

[12] The viscosimeter used was made from a brass tube with an outside diameter of two inches and walls 0.05 inch thick. A two-inch rubber stopper was placed in the bottom of the brass pipe, and a piece of glass tubing one inch long and having an inside diameter of 0.20 inch, was put through the center of the stopper as an orifice. The top end of the glass was heated and made slightly funnel-shaped, and then pulled down till level with the rubber surface. A small cork was used as a stopper in the end of the glass tube. The instrument was made to deliver 200 cc. of water, the time of efflux being 8.8 seconds. When in use, the viscosimeter was open at the top. It was found desirable to keep the viscosity between two minutes and thirty seconds and four minutes, for good casting. This was difficult in some cases, because of the difficulty of agitating sufficiently, since all agitation was by hand. For this reason probably all of the viscosities could be lowered with longer and more thorough agitation.

A 200-cc. flask, cut off squarely at the calibration mark, was used as a weighing bottle. This was filled with slip and weighed, and the density obtained to the nearest hundredth of a gram per cubic centimeter. Desirable density was found to be about 1.80, and the densities obtained varied from 1.75 to 1.81.

and spalling or dunting of the bodies. The glaze used was a cone 5 to 7 fritted sanitary ware glaze with the following molecular formula:

$$\left.\begin{matrix}0.350\ ZnO\\0.135\ CaO\\0.325\ PbO\\0.095\ Na_2O\\0.095\ K_2O\end{matrix}\right\}\ 0.245\ Al_2O_3\ \left\{\begin{matrix}2.750\ SiO_2\\0.200\ SnO_2\end{matrix}\right.\ 0.270\ B_2O_3$$

This glaze was applied in a thin coat, by dipping, to two pieces of each of the six bodies and fired in an assay-muffle furnace to cone 6 in 10 hours, holding at the finishing temperature for about 30 minutes. The crazing test used to determine glaze-fit was a modification of that described by

TABLE VI

RESULTS OF TESTS ON TRIAL BODIES IN SLIP AND DRY CONDITIONS

	Slip data		Dry data			
Body	Sp. gr. (g./cc.)	Viscosity, (min. sec.)	V.D.S.* (%)	C.L.D.S.† (%)	D.T.S.‡ (lb./sq. in.)	Remarks
S	1.80	2′50″	12.0	3.8	283	
A-1	1.79	5′00″	14.9	4.7	335	Slip jells slightly
A-2	1.76	4′40″	17.7	5.5	303	Slip jells
B-1	1.75	5′20″	19.8	6.2	414	Slip jells and "livers"
B-2	1.75	5′00″	19.1	6.0	280	" " " "
C-1	1.77	3′00″	13.3	4.2	270	
C-2	1.75	3′15″	12.0	3.8	210	
C-3	1.78	5′30″	14.7	4.7	301	
C-4	1.79	6′10″	12.9	4.1	317	
D-1	1.75	4′10″	15.6	5.0	321	
D-2	1.75	6′30″	15.8	5.0	228	Slip jells slightly
E-1	1.77	6′10″	15.6	5.0	330	" " "
E-2	1.80	5′00″	12.8	4.0	345	
E-3	1.80	5′40″	14.0	4.5	320	
E-4	1.78	4′15″	16.3	5.2	362	" " "
F-1	1.79	3′40″	11.6	3.7	381	
F-2	1.77	High	21.1	6.5	342	Coning or balling in cast piece due to jelling.
F-3	1.77	High	23.5	7.3	299	
F-4	1.77	3′45″	14.7	4.8	341	
G-1	1.79	3′30″	11.1	3.6	345	

* V.D.S. per cent = volume drying shrinkage (% dry).
† C.L.D.S. per cent = calculated linear drying shrinkage (% dry length).
‡ D.T.S. = dry transverse strength (modulus of rupture).

Sortwell.[13] The quenching medium was tap water, at a temperature of 25°C. The first quench was from a temperature of 125°C. Successive temperatures were 25° higher than the one before, and three quenches were made at each temperature, or until crazing took place.

The test for spalling or dunting was conducted in the same manner as that for crazing. A biscuited piece of each of the six bodies and an unglazed sample tile from a local factory were tested. The quenching was in tap water, the first being from 150°C, the second from 200°C, and so on in 50° increments, until cracks were detected when the pieces were painted

[13] H. H. Sortwell, "Comparative Tests of American and Foreign Table Ware," *Jour. Amer. Ceram. Soc.*, **5**, 279 (1922).

TABLE VII

RESULTS OF TESTS ON FIRED TRIAL BODIES

Body	Fired to cone	V.F.S.* (%)	C.L.F.S.† (%)	Total C.L.S. (%)	Apparent density (g./cc.)	Absorption (%)	Apparent porosity (%)	Remarks
S	9½	30.3	11.3	14.5	2.38	0.56	1.32	Not vitrified
	10½	31.6	11.9	15.1	2.43	0.11	0.26	Very good color; high firing shrinkage
	11	31.8	12.0	15.2	2.44	0.06	0.16	
	10+	33.0	12.5	15.7	2.47	0.07	0.16	Commercially fired
A-1	9	17.3	6.1	10.3	2.04	9.50	19.4	Not vitrified and poor in color
	10½	22.6	8.2	12.3	2.17	5.47	11.8	
	11	23.5	8.5	12.6	2.20	4.38	9.62	
A-2	9½	22.4	8.1	12.9	2.12	7.05	14.9	Not vitrified and color only fair
	10½	24.6	9.0	13.7	2.18	4.81	10.5	
	11	25.2	9.2	13.9	2.19	4.61	10.1	
B-1	9	26.1	9.6	14.9	2.18	4.70	10.4	Not vitrified. Color very poor and too much shrinkage
	10½	30.1	11.2	16.4	2.30	0.61	1.38	
	11	31.1	11.7	16.8	2.33	0.20	0.45	
B-2	9½	24.5	8.9	14.1	2.14	6.34	13.6	Same as for A-1
	10½	27.4	10.1	15.2	2.22	3.31	7.35	
	11	27.5	10.2	15.3	2.23	3.01	6.70	
C-1	9	21.1	7.6	11.3	2.09	8.10	16.9	Same as for A-1
	10½	24.7	9.0	12.7	2.19	5.35	10.3	
	11	25.2	9.2	12.9	2.21	4.70	8.49	
C-2	11½	30.2	11.3	14.5	2.32	0.60	1.38	Vitrification and color fair
C-3	9	22.9	8.3	12.4	2.16	6.10	13.3	Not vitrified and color fair
	10½	26.5	9.7	13.8	2.26	2.90	6.53	
	11	26.7	9.8	13.9	2.27	2.35	5.34	
C-4	9	21.1	7.6	11.2	2.15	7.15	15.3	Same as for C-3
	10½	24.9	9.1	12.7	2.25	3.70	8.53	
	11	25.4	9.3	12.9	2.26	3.10	7.10	
D-1	9	21.6	7.8	12.2	2.13	6.79	14.4	Not vitrified, but color is good
	11	24.6	9.0	13.3	2.20	4.14	9.13	
	12	26.3	9.7	14.0	2.25	2.64	5.90	
	10+	25.4	9.3	13.6	2.21	3.64	8.03	Commercially fired
D-2	9	23.2	8.4	12.8	2.14	6.32	13.6	Same as for D-1
	11	26.7	9.8	14.1	2.24	3.84	8.60	
	12	28.9	10.7	15.0	2.31	2.14	4.94	
	10+	28.0	10.4	14.7	2.26	2.80	6.33	Commercially fired
E-1	9	21.8	7.9	12.3	2.13	6.90	12.5	Same as for D-1
	11	25.9	9.5	13.8	2.25	2.84	6.37	
	12	27.0	10.0	14.3	2.28	1.87	4.23	
	10+	26.5	9.7	14.0	2.25	2.71	6.08	Commercially fired
E-2	9	22.7	8.2	11.7	2.14	5.28	11.4	Not completely vitrified, but good color
	11	25.5	9.3	12.8	2.22	2.97	6.58	
	12	27.0	10.0	13.5	2.27	1.82	4.13	Color is good
	10+	26.9	9.9	13.4	2.26	1.73	3.89	Commercially fired
E-3	9	26.1	9.6	13.5	2.24	3.44	7.68	Not vitrified
	11	28.7	10.7	14.5	2.32	1.68	3.92	
	12	30.0	11.2	15.0	2.36	0.08	0.19	Vitrified and good color
	10+	28.7	10.7	14.5	2.32	0.62	1.42	Commercially fired
E-4	9	25.2	9.2	13.7	2.24	3.04	6.80	Same as for E-3
	11	28.2	10.4	14.8	2.33	0.64	1.46	
	12	29.1	10.8	15.2	2.35	0.06	0.14	
F-1	9	23.8	8.7	12.0	2.27	2.41	5.47	Not vitrified
	11	25.9	9.5	12.7	2.33	0.86	1.99	
	12	27.7	10.2	13.4	2.40	none	none	Completely vitrified and good color
F-2	9	27.7	10.2	15.7	2.31	0.40	0.91	
	11	29.1	10.8	16.2	2.35	0.05	0.11	Excellent color; too much shrinkage
	12	29.6	11.0	16.4	2.37	0.02	0.04	
F-3	9	29.5	11.0	17.0	2.32	0.05	0.10	Same as for F-2

TABLE VII (*Concluded*)

RESULTS OF TESTS OF FIRED TRIAL BODIES

Body	Fired to cone	V.F.S.* (%)	C.L.F.S.† (%)	Total C.L.S. (%)	Apparent density (g./cc.)	Absorption (%)	Apparent porosity (%)	Remarks
	11	29.7	11.1	17.1	2.32	0.27	1.00	Slightly cracked
	12	28.3	10.5	16.6	2.28	0.02	0.05	Slightly blistered
F-4	9	26.3	9.7	13.8	2.27	2.24	5.07	Not vitrified
	11	27.2	10.0	14.1	2.30	0.58	1.32	Color good, but fuses on edges
	12	29.7	11.1	15.2	2.37	0.07	0.16	
G-1	9	25.7	9.4	12.5	2.30	1.93	4.43	Not vitrified
	11	27.6	10.2	13.3	2.38	0.37	0.87	Vitrified, and very good color
	12	29.2	10.9	14.0	2.43	none	none	

* V.F.S. = volume firing shrinkage (% dry volume).
† C.L.F.S. = calculated linear firing shrinkage (% dry length).

with red ink. This is not known to be a standard test for whiteware but it is thought to be of value because the spalling or dunting point of the biscuit no doubt limits the crazing resistance of the glazed piece.

Results The results are given in Tables VI and VII. The slip and dry data show that any appreciable amount of the Lincoln fire clay (No. 288) in the body causes coagulation, with a correspondingly high drying shrinkage. The difficulty of obtaining sufficient deflocculation of this clay makes it undesirable as an ingredient of cast ware.

Tennessee ball clay and the Alberhill ball clay (No. 273) seem to have about the same effect on the slip and dry properties. The presence of English ball clay in most cases makes possible either a higher density or a lower viscosity, for the reason that it is so readily deflocculated.

The substitution of the Ione washed clay (No. 317) for English china clay, in amounts over 20 to 25% noticeably increases the viscosity of the slip, but, providing the other constituents are wisely chosen, this seems to have no bad effects on the casting properties. For example, body E-2 contains 35% of Ione clay, but combined with English ball clay it gives good results. This substitution also considerably increases the dry transverse strength, as is shown by a comparison of bodies S and E-1.

It was found in subsequent work that sufficient agitation was all that was necessary to lower the viscosity of slips containing No. 317 clay. A body similar to S required 0.15% of deflocculents to obtain a good casting viscosity, while a body containing 12% of No. 317 clay required 0.18% of deflocculating agents to obtain the same result.

An increase in the percentage of nonplastics, *i.e.*, feldspar or flint, at the expense of the clay content lowers the viscosity, the drying shrinkage, and the dry transverse strength, as is illustrated by body C-2.

The addition of the carbonates of calcium and magnesium makes the slip viscous, and causes jelling and high shrinkage. The effect of sodium

chloride is similar, but to a lesser degree. The addition of finely-ground biscuited material, on the other hand, gives an increase in weight and a decrease in viscosity and drying shrinkage. Four per cent of this substance added to the body did not lower its dry strength, even though it is non-plastic.

In general, the viscosity and jelling tendency of the slip seem to govern the drying shrinkage. There are two reasons for this: (1) If the slip jells, the feeder in the casting mold is shut off before the piece has had a chance to cast solid, and (2) if the viscosity is high, indicating poor dispersion, the porosity of the dried piece is increased. In this respect the viscosity is much more important than the density of the casting fluid. Body C-2, having low density and viscosity, also has a small percentage of shrinkage; while bodies F-2 and F-3, having comparatively higher densities, shrink a great deal more because of their very high viscosities. This would indicate that in plant practice it is more important to control closely the slip viscosity than to keep the density constant.

Results of Tests on Fired Bodies

The undesirability of the Lincoln clay (No. 288) is again apparent in the fired trials. It gives a dirty buff-white color and increases the shrinkage a great deal. It does, however, lower the vitrification temperature of the body, and would probably be a good constituent of stoneware.

All bodies containing an appreciable amount of the California ball clay (No. 273) are very difficult to vitrify and their color is a pale buff-white. These two properties make it undesirable as a vitreous china sanitaryware ingredient. Of the ball clays, the English and Tennessee clays are the best agents of vitrification, the former being the better of the two.

The substitution of washed, California clay (No. 317) for English china clay, in amounts greater than 20% of the mix, raises the vitrification temperature appreciably, but this effect can be lessened by increasing the English ball clay content. Vitrified bodies in which the above substitution has been made, seem to have suffered no degradation in color.

The addition of magnesium and calcium carbonates to the body mix results in a lowering of the vitrification temperature, and an improvement in the whiteness of the fired ware. A total of 2% of these carbonates was excessive as it caused blistering. Sodium chloride causes fusion of the fired pieces on the corners and edges.

Ground biscuited ware, added to the body, to the extent of about 4% lowers the firing shrinkage and has very little effect on the absorption; this is illustrated by body F-1 in comparison with E-4.

Body G-1, containing a combination of English china and washed California clays gave very good results. Its shrinkage is less than that of the standard body, and its vitrification is about equal to it. The color is as good if not better.

Comparing the results of the test pieces fired at a local sanitary-ware plant with those fired in the laboratory, it can be seen that the laboratory schedule requires a temperature of about one cone higher to give the same results. The pieces fired to cone 11 in the laboratory, therefore, have had the equivalent of a commercial firing of approximately cone 10. The absence of a longer soaking period in the laboratory firing schedule results in a lower shrinkage than that obtained in commercial firing.

Since no standard test for vitrification of sanitary ware could be found, the desired condition was arbitrarily set at a maximum absorption of 1% when fired to cone 11 in the laboratory. All the bodies passing this test, with the exception of the standard body and body B-1, which was eliminated because of poor color, are grouped at the end of Table VII. Body E-3 is included because of its low absorption when fired commercially. Although it is probably the best method for determining vitrification at the present time, the absorption test does not seem to give accurate and positive results. One body which is apparently more nearly vitrified than another will often show a much higher percentage of absorption; most bodies, however, having less than 0.50% absorption are well vitrified. The red ink test is too severe for practical purposes. Several pieces with less than 0.10% absorption were stained by red ink.

The five best trial bodies are E-3, E-4, F-1, F-2, and G-1. These were tested along with body S for fired transverse strength, and gave the following results:

Body Fired to cone 11 (in laboratory)	Fired modulus of rupture (lb./sq. in.)
S	5,540
E-3	3,920
E-4	5,000
F-1	4,600
F-2	3,790*
G-1	7,040

* This value is low because of balling or coning in the cast piece. The body is probably as strong as S.

The glaze-fit test gave the following results:

RESULTS OF GLAZE-FIT AND SPALLING OR DUNTING TESTS

Glazed body	Crazing temperature and quench	
S	225°C	First
E-3	175	Third
E-4	175	First
F-1	175	Third
F-2	175	First
G-1	200	Second
Sample piece from local plant	200	First

According to Harkort[14] all of these glazes are fairly good, but those resisting crazing up to 200°C are very good. All the crazing was rather slight.

The spalling or dunting test resulted in all the bodies, S, E-3, E-4, F-1, F-2, G-1, and the sample biscuit piece from a local plant, showing cracks when tested with red ink after quenching in tap water from a temperature of 250°C. Body E-4 was cracked the most and bodies G-1 and S were least affected. The commercial body appeared about the same as F-1.

Discussion

From the results obtained, it is apparent that the molecular formula of the body cannot be relied upon to forecast the quality of the body. Most of the mixtures tried had nearly the same formulas, but their dry and fired properties were widely variant. A slight change in the amount of fluxes present has a much greater effect on the finished ware than has a similar change in the silica or alumina content. This is shown by the effect of additions of magnesium and calcium carbonates.

The tests on the raw materials, which give results most indicative of their influence on the body mixture, seem to be those from the dry and fired properties and the deflocculation test on the clays. The influences of the English and Tennessee ball clays are very much as would be expected from the results of the above tests made on them.

There seems to be no reason for keeping within Seger's "area of practical whiteware body compositions;" *i.e.*, 8 to 20% feldspar, 4 to 52% clay, and 28 to 52% flint.[15] Most vitreous china sanitary-ware bodies contain more than 20% feldspar, and providing the slip, dry, and fired properties are entirely satisfactory, and a good glaze-fit is obtainable, there is no technical reason why the composition of a body should be restricted to certain limits. For example, body C-2, containing 30% feldspar, was overfired to as high a temperature as cone 13, and was neither warped nor blistered. Body S, with the same amount of feldspar, would warp and probably blister at cone 11. The batch formula depends, to a large extent, upon the constituent raw materials and, since the properties of these may differ greatly, it is reasonable to expect that good results may be obtained within a wide range of molecular formulas, even for the same class of products.

Bodies which are difficult to vitrify or poor in color, benefit greatly from the addition of small amounts of magnesium and calcium carbonates. It is thought that they could be added in amounts up to a total of 1%, in the ratio of three parts of the magnesium carbonate to two of the calcium car-

[14] H. Harkort, "A Method of Testing Crazing of White Ware," *Trans. Amer. Ceram. Soc.*, **15**, 368 (1913).

[15] *Trans. Amer. Ceram. Soc.*, **13**, 448 (1911).

bonate, and the jelling effect on the slip overcome by further addition of sodium silicate. More than 1% is not recommended because of the difficulty of deflocculation and the liability of the ware to blister. Sodium chloride seems to have much less effect on the color than these other salts, and is undesirable because of efflorescence, causing fusion on the edges and corners.

The addition of finely-ground biscuited scrap, although it raises the vitrification temperature very slightly, more than makes up for this by lowering the shrinkages and improving the casting slip. This is a material which is available at all plants to the extent of several per cent, depending on the biscuit losses. It is made into a useful ingredient for the cost of grinding. Although extensive tests were not made, it is probable that ground biscuit could be added, without harmful effect, in an amount equal to 5 or 6% of the mix.

The vitrification ranges of all the five best trial bodies are sufficiently long to be safely fired under commercial conditions. It is thought that the results of most of the tests would be more satisfactory if made on the same bodies manufactured commercially. In the laboratory, agitation of the slip is more difficult, and heating and cooling rates more rapid, subjecting the bodies and glazes to greater internal stresses.

It is difficult to introduce anything more than a minor change into the sanitary-ware industry, because of its empirical nature. The body mixtures in use in the California plants today are very much the same as those brought over from England when the industry first started in this country.

The substitution of a local clay, such as No. 317, for English china clay, would result in a considerable saving in the manufacturing cost of the ware. It could probably be obtained for little more than half the cost of a good grade of the English clay, the price depending upon the location of the consumer. In California, the raw materials represent about 15% of the manufacturing cost. If the local clay cost half as much as the foreign clay replaced, and a substitution of 20% of the body mixture were made, the net result would be a saving of about 1.5% in the total cost of production.

It is probable that the exploitation of the Amador County deposit could be made profitable if the price received for the washed clay were $12 to $15 per ton on cars; whereas the cost in California, of most English china clays, is more than $20 per ton. The coarse product, comprising about 50% of the raw clay as mined, is a good refractory material, and could no doubt be sold to manufacturers of fire brick and similar products for $1.50 to $2.00 per ton, on cars.

Test Work in Commercial Plant

Preliminary tests in a commercial plant were begun by substituting the washed clay for about 5% of ball clay and from 0 to 25% of English china

clay, as it was felt that the added dry strength resulting from the substitution of the Ione washed clay for English china clay was not particularly advantageous, while substitution for a ball clay would result in an improvement in color. The results showed that an increasing amount of the California clay increased the refractoriness of the body. To overcome this, the second set of trials featured the substitution of feldspar for silica. The silica ranged from $24^1/_4$ to $13^3/_4$% and the feldspar from $27^1/_2$ to 38%. The constituent clays were held constant in this series; 24% of the California clay being present at the expense of approximately 12% each of Tennessee ball clay and English china clay. The body containing 20% of silica and $31^3/_4$% of feldspar seemed to be as well vitrified as those with a higher feldspar content, but none of them were completely vitrified.

Owing to the presence of black specks in the feldspar, it was desired to keep this constituent as low as possible and yet obtain vitrification; so the next series of tests was based on the preceding set, with the silica content fixed at $22^1/_4$% and the feldspar content fixed at $29^3/_4$%, while the ball clay was increased in steps of 1% at the expense of the washed clay. In these trials, the washed clay replaced 12% of the English china clay and from 8 to 12% of the Tennessee ball clay, the remainder of the Tennessee clay being replaced by English ball clay. The substitution of the English ball clay for the California clay darkened the body, making this method of hastening vitrification undesirable.

The fourth set of trials was based on the substitution of the California clay for part of the clay content of a commercially satisfactory body, without changing the ratios among the clays replaced, and a simultaneous replacement of part of the silica by feldspar. Accordingly, two bodies were made containing:

	(1)	(2)
Feldspar	32.00%	32.00%
Silica	20.25	20.25
China clay	28.75	13.75
Ball clay	19.00	9.00
Ione washed clay		25.00

These two bodies were blended giving a series of mixtures containing 0, 5, 10, 15, 20, and 25% of the California clay. The first member of this series was more translucent than the regular plant body, which had a translucency between those of the second and third members. The first four of the series were well vitrified. The fifth in the set, containing 20% of California clay, was not completely vitrified, while the one with 25% of this clay was considerably underfired.

A large batch composed of 30% feldspar, $21^1/_4$% silica, $21^1/_4$% English china clay, $6^1/_2$% English ball clay, $8^3/_4$ %Tennessee ball clay, and $12^1/_4$% washed California clay, was prepared, and two tank and bowl sets were

cast. These pieces cast slightly slower than the same pieces using regular plant slip, and when cast were a little harder.

There was no dunting in these heavy pieces, and the fired color was very good. Vitrification seemed to be complete at the temperature of cones 10 to $10^1/_2$. The presence of the washed clay seemed to decrease the tendency of the body to warp.

It is suggested that any plant considering the use of Ione washed clay in a whiteware body, might work along the following lines: substitute $4^1/_2\%$ of the clay for $2^1/_2\%$ of china clay, $1^1/_2\%$ of ball clay, and $^1/_2\%$ of silica, and simultaneously replace 1% of silica with 1% of feldspar. In this way it is thought that 15 to 18% of the washed clay might be profitably used in a whiteware body.

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Compiled by the

AMERICAN CERAMIC SOCIETY

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Abrasives

Abrasives depicted in motion picture film. ANON. *Abrasive Ind.*, **11** [1], 25 (1930).—The important rôle which grinding and polishing operations play in making numerous everyday articles is pictured in an educational motion picture film, "Manufactured Abrasives." Copies of this film may be obtained for exhibition purposes by applying to the Pittsburgh Experiment Station, U. S. Bureau of Mines, Pittsburgh. No charge is made for the use of the film. E.P.R.

Natural and artificial abrasives in Canada. ANON. *Can. Chem. Met.*, **13** [12], 31 (1929).—During 1928, nine companies produced natural abrasives in Canada, and twelve manufactured artificial abrasives, representing a total capital investment of $7,765,723. The selling value of the natural abrasives produced amounted to $119,715 in 1928 as compared to $132,552 in 1927. Included in this group are the following materials: (1) diatomite, 368 T., valued at $8960; (2) garnets, on which experimental shipments have been made during development work; (3) grindstone, pulpstone, and scythestones totalling 1855 T., valued at $100,960; (4) volcanic dust, valued at $9795 for 485 T. in 1928 as compared with 105 T. valued at $735 for 1927. Artificial abrasives valued at $7,122,588 were manufactured in 1928, compared with $6,106,794 in 1927, the principal items being fused alumina, $3,786,113; crude silicon carbide, $2,098,199; abrasive wheels, $847,489. E.J.V.

Correct wheel speeds. ANON. *Abrasive Ind.*, **11** [1], 40–41 (1930).—Demands for increased production are not confined to precision grinding alone as the lately developed high-speed wheels have been found to increase the output of snagging operations materially. This has led to the development of rigid machines for rough-grinding operations. E.P.R.

Wheel balancing. ANON. *Abrasive Ind.*, **11** [1], 30 (1930).—An illustrated booklet, "The Balancing of Grinding Wheels," has been issued by the Norton Co. (Worcester, Mass.). The booklet was written with the idea of helping users of grinding wheels to get more and better work from wheels and to maintain grinding machines in better condition. Part I is devoted to the balancing of wheels used for precision grinding operations; Part II, to the balancing of wheels for offhand grinding. E.P.R.

Grinding appliances of other days. ANON. *Abrasive Ind.*, **11** [1], 48 (1930).—To visualize the progress made in grinding during the past half century, a study must be made of the important industries of other days wherein abrasives were employed extensively. The ax factory furnishes an example. A view of the grinding room of the Underhill Edge Tool Co. (Nashua, N. H.), as it appeared in the year 1880 is reproduced. E.P.R.

Special equipment grinds locomotive valve-motion links. ETHAN VIALL. *Abrasive Ind.*, **11** [1], 15–17 (1930).—Locomotive valve link grinding is strictly a machine job, and whenever possible a standard grinding machine made for the purpose should be used. Some of the grinding apparatus used in one of the shops of the Chicago, Minneapolis, & St. Paul Railroad is described with illustrations. E.P.R.

Grinding metal-cutting tools. ANON. *Abrasive Ind.*, **11** [1], 22–25 (1930).—Greater stress should be laid on the adoption of a correct and uniform method of grinding tools for production work. To secure best results, the following points must be carefully observed; (1) The tool must be heavy enough to take the cut without appreciable chatter. (2) The various angles of clearance and rake must be correctly proportioned to turn the chip properly and to preserve the cutting edge. (3) The tool must be located accurately in relation to the work and firmly clamped. The importance of these factors and their relation to various types of cutting tools is illustrated by diagrams. E.P.R.

Grinding accurate angle irons. ANON. *Abrasive Ind.*, **11** [1], 17–18 (1930).—Ordinary angle irons in the tool cribs of average machine shops are not always accurate. The methods followed in making accurate angle irons from chilled iron or hardened steel by the grinding method are described. Such angle irons remain accurate longer than the soft variety and they always can be refinished at slight expense. E.P.R.

Two new electric grinding units. ANON. *Abrasive Ind.*, **11** [1], 43 (1930).—Van Dorn Electric Tool Co. (Cleveland, Ohio) announces a 7-in. flexible disk grinder and 7-in. bench grinder. The grinder is provided with a removable pipe handle and right- and left-hand bosses, making it possible to change the grinder quickly and easily for right- or left-hand operation. The bench grinder is suitable for sharpening all kinds of edge tools and light grinding work. E.P.R.

High-speed grinders. ANON. *Abrasive Ind.*, **11** [1], 43 (1930).—The Hisey-Wolf Machine Co. (Cincinnati, Ohio) describes high-speed grinders equipped with tex-rope drives, also a single-speed machine in three sizes, and a multi-speed machine, equipped with a 10-H.P. motor designed to use 24-in. wheels, operating at 9500 surface ft. per min. E.P.R.

Grinders. ANON. *Abrasive Ind.*, **11** [1], 43 (1930).—Cincinnati Grinders, Inc., describes two types of centerless grinders, gives illustrations, and calls attention to automatic hoppers for centerless grinders. The advantages of a battery of grinders being fed by these devices are described. E.P.R.

Grinders. ANON. *Abrasive Ind.*, **11** [1], 43 (1930).—Oesterlein Machine Co. (Cincinnati, Ohio), describes precision features of grinders, illustrates details by progressive steps, and shows advantages of grinding tools with a solid-backed cutting edge. E.P.R.

Grinders. ANON. *Abrasive Ind.*, **11** [1], 43 (1930).—Chicago Pneumatic Tool Co. has a new type rotary, air-powered, light-weight, portable grinder. Sectional views are shown. E.P.R.

New features for grinder. ANON. *Abrasive Ind.*, **11** [1], 41–42 (1930).—A new cutter grinder which embodies many new and improved features of convenience, accuracy, and rigidity is described. E.P.R.

Grinder transmission is V-disk type. ANON. *Abrasive Ind.*, **11** [1], 42 (1930).—A new type of grinder for high-speed snagging work, operating on alternating current and employing a new method of power transmission known as the V-disk transmission is described. The transmission consists of a series of meshing disks on the motor shaft and spindle, the disks being made of graphitized micarta, a material similar to that used in automobile timing gears for noiseless operation. A feature of the grinder is its ability to maintain an average peripheral speed or wheel-surface speed of approximately 9000 ft. per min., using vitrified or high-speed wheels down to the flanges. This is accomplished by proper manipulation of the transmission. E.P.R.

Semi-automatic disk grinders increase spring production. ANON. *Abrasive Ind.*, **11** [1], 26 (1930).—The grinding of the ends of heavy coil springs is a production operation that has been expedited through the use of semi-automatic equipment. Methods followed at the plant of the American Spiral Spring Mfg. Co. (Pittsburgh) are described. The illustrations were furnished through the courtesy of the Gardner Machine Co. (Beloit, Wis.), manufacturers of the equipment described. E.P.R.

German cutlery manufacturer designs modern equipment. J. A. HENCKLES. *Abrasive Ind.*, **11** [1], 44–45 (1930).—Some of the operations followed in knife manufacture are illustrated and described briefly. It is noted that the modern as well as the time-honored methods of other days are employed. E.P.R.

Ground threads. ANON. *Abrasive Ind.*, **11** [1], 43 (1930).—John Bath &

Co., Inc. (Worcester, Mass.), has issued an illustrated booklet, "Ground Thread Handbook," featuring the method of thread grinding from the solid after hardening. E.P.R.

Brake drums ground economically. ANON. *Abrasive Ind.*, **11** [1], 38 (1930).—Much improvement over previous models is reflected in the brake-drum grinder, a product of the Cincinnati Grinders, Inc. The machine retains all the valuable features of previous models together with a number of improvements for the safety of the operator. E.P.R.

Abrasive processes expedite marble production. J. P. MCCLUSKEY. *Abrasive Ind.*, **11** [1], 19–21 (1930).—M. describes quarrying operations and explains how marble blocks are sawed into slabs. He also describes the grinding, rubbing, and polishing operations. Data on the production of moldings, columns, fluted and curved work, in lathe and planer type abrasive machines equipped with carbide of silicon wheels are included. E.P.R.

Abrasive drills largest optical lens. ANON. *Abrasive Ind.*, **11** [1], 27 (1930).—Perkins Observatory at the Ohio Wesleyan University (Delaware, Ohio) is said to have the largest disk of optical glass ever manufactured in the U.S. This disk is 70 in. in diameter and 11 in. thick. The type of mounting for which the reflector was designed required a hole 8 in. in diameter through the optical axis of the glass. The task of drilling was accomplished with an 8-in. brass tube attached to a radial drill, using silicon carbide and water. Seventy hours were required to drill the hole. See also *Ceram. Abs.*, **8** [12], 819 (1929). E.P.R.

Photographic specimen grinder. ANON. *Abrasive Ind.*, **11** [1], 28–30 (1930).—The object of the invention is to improve the construction and operation of machines of the type used in producing smooth, plane surfaces on objects usually of relatively small dimensions, and to facilitate the process of polishing, particularly where a large number of specimens are handled. It has three polishing units arranged for convenient operation. The assembly includes a bench with frame members supporting a bench top, the top being provided with circular apertures within which are mounted metal rings for supporting the individual grinding or polishing units. E.P.R.

Polishing wheels. ANON. *Abrasive Ind.*, **11** [1], 43 (1930).—Frederic B. Stevens, Inc. (Detroit, Mich.), describes felt-polishing wheels. E.P.R.

Endless polishing belts. ANON. *Abrasive Ind.*, **11** [1], 31 (1930).—The Russell Mfg. Co. (Middletown, Conn.), has issued a 24-page booklet on endless woven belts. In addition to information and illustrations of the line in general, many useful facts for the grinding and polishing trade are given. Tables are included, showing belt sizes for the more widely used machines and complete data are given relative to the correct method for coating abrasive belts. E.P.R.

Polishing lathe with gear drive. ANON. *Abrasive Ind.*, **11** [1], 39–40 (1930).—The usual practice followed in designing a polishing or buffing lathe fitted with an a.c. motor is to install the motor in the base and transmit power to the wheel spindle through the medium of a belt drive. The lathe described is a departure from conventional lines as the motor is mounted at the top of the base and the drive carried through herringbone gearing, one set of gears being supplied to each wheel spindle. The object of this construction is to eliminate both the vibration and undue strain from the motor bearings and any liability of damaging the motor by the rotor striking the fields or stator should the spindle bearings wear unduly. E.P.R.

Rhenish pumice stone. WILLI SERKIN. *Tonind.-Ztg.*, **53** [85], 1511–12 (1929).—A report on the mining and preparation of pumice, which deposits are located between Eifel and Westerwald, Germany. Several analyses of schistose and nonschistose pumice are given. M.V.K.

PATENTS

Grinding. LEWIS R. HEIM. U. S. 1,741,236, Dec. 31, 1929. In grinding apparatus, in combination, a work support, a guide, means supporting the guide adjacent the lower edge thereof and mounting the guide to swing about a substantially horizontal axis toward and away from the work support, and means adapted to lock the guide in the position into which it is swung.

Roll grinder. HENRY E. P. TAYLOR. U. S. 1,742,736, Jan. 7, 1930. In combination with a grinding machine having a pair of grinding wheels disposed one on either side of the work to be ground, transversely swingable means supporting the wheels, the wheels being pivotally supported thereon for tilting movement toward and away from the work to be ground, and means to tilt the wheels in unison including a rockable member having part of its periphery eccentric to its axis and operably connected to both of the wheels.

Motor-driven machine. WILLIAM C. HAMMOND AND HENRY J. KINGSBURY. U. S. 1,743,134, Jan. 14, 1930. The combination of a chambered pedestal, an electric motor mounted on the pedestal and comprising a rotor provided with a fan and a housing having an air-discharge opening and an air filter within the pedestal connected to the motor housing to deliver filtered air thereto.

Adapter for segmental abrasive wheels. FRANK O. HOAGLAND. U. S. 1,743,604, Jan. 14, 1930. An abrasive wheel comprising in combination, a ring member having an integral flange, adjustable bearing members positioned within the flange, adapter members having abrasive segments secured therein, and clamping means to retain the adapter member in position against the bearing members in the flange.

Centerless grinding. K. O. LEON. Brit. 320,912, Dec. 18, 1929. The work carrier of a centerless grinding machine, which supports the work between a grinding wheel and a regulating wheel is arranged to contact with the work at two or more spaced points or lines below the axis of the work.

Lubricating grinding or abrading surfaces. CARBORUNDUM CO., LTD. Brit. 321,240, Dec. 27, 1929. The surface of a bonded abrasive article, *e.g.*, a grinding wheel or abrasive cloth or paper is treated with a lubricant (a fatty organic acid) which has the property of spreading readily over that surface. The lubricant may be used by itself, or mixed with oils, waxes, fats, or resins either by emulsifying or by solution; it may be applied also as a continuous lubricant, being then used as a constituent of a lubricant consisting largely of mineral oil. The lubricant also may be made up in block form for application to the abrasive surface, or a grinding wheel may be dipped in the lubricant (oleic acid). Other suitable lubricants are sulphonated oils, of which sulphonated pine oil is an example.

Grinding toothed gears. F. B. DEHN. Brit. 321,251, Dec. 27, 1929. In a method of grinding toothed gears by means of an abrasive screw which is rotated in timed relation with the blank and acts in the manner of a hob, the abrasive screw is moved longitudinally during operation to distribute the wear thereon, while the gear blank is also fed axially until the teeth are completely formed. A slide moving on ways carries an adjustable supplemental slide having an arcuate guide on which slides a member carrying the bearing for the spindle of the grinding hob. The member may be angularly adjusted according to the inclination of the threads on the grinding hob and, in the case of spiral gears, the angle of the teeth to be cut in the blank. The hob is moved axially during the operation in order to distribute the wear over a number of threads, compensating movement being applied to the gear train for rotating the work. On completion of the operation, the hob is withdrawn from the work by means of a cam acting on a slide and the work spindle is quickly returned.

Art

Faience and potteries of Old France.* C. H. MITCHELL. The faience of Old France occupies a unique and distinct place in the development of the ceramic art of Europe. It formed the foundation of that great artistic ceramic period of the 17th and 18th Centuries, for which France has become famous. By faience is meant that ware made of the ordinary local clays of France from which all ware were produced previous to the Revolution. Historically it followed gradually and naturally from the Italian, through Majolica and from the Oriental through Delft ware in French endeavors to imitate these. Technically the term faience comprises all that group of pottery which is formed of clay material having a soft and porous texture and which is coated over with a thick opaque enamel or glaze. In the earlier days this glaze was done by means of lead and later by tin. The latter, called stanniferous enamel, comprised the greater part of the real French faience throughout the reigns of Louis XIV, Louis XV, and Louis XVI, that is from 1634 to the Revolution of 1792. The termination of the faience period was distinctly marked, not on account of political troubles, but because of the discovery of porcelain clay in France, which was just before the Revolution. The introduction of porcelain made possible the rapid development of the Rouen, St. Cloud, Chantilly, and Vincennes factories, the latter being the forerunner of the world renowned Sèvres porcelain factory which was created a royal establishment not long before the revolution. The French potteries of these early days, while receiving inspiration of design and technique from Majolica and Delft, developed their unique characteristics before the German Dresden and long before the English Chelsea, Worcester, Derby, or Wedgwood.

Discussion: Design problems of the tableware industry.* Led by ARTHUR E. BAGGS AND MARION L. FOSDICK. A preliminary report of the Art Division, Committee on Tableware, presented not as a finished contribution but as a suggestion of points for discussion regarding one of the most vital factors in the future success of American tableware. The following topics are considered: (*a*) The need for improved design as a merchandising factor. (*b*) Present sources of tableware design. Are they adequate for the manufacturer's needs? (*c*) Production methods and decorative processes, their possibilities and limitations. (*d*) The price factor as a limitation to decorative treatment. Cannot better design lift certain ware out of the closely competitive price-shaving class without great increase in production cost? (*e*) Types of ware which seem best suited to modern demands. (*f*) The training of ceramic designers in the schools. What general and specific training will best fit the prospective designer to function effectively in the industrial plants. (*g*) Suggestions regarding a definite program of coöperative work on the tableware design to be undertaken by the schools and the factories.

Color understanding of uniform scales of color.* WALTER M. SCOTT. In this paper color is first defined according to the scientific and also according to the popular conception of the term. The production of color or colors by pigment mixture, by the combination of colored lights, and by the blending of colored disks by spinning is then discussed. Various systems for the measurement and specification of color have been evolved from the known methods of color production and from the relationships which exist between color and light. These systems are briefly described with particular emphasis on the distinction between physical measurement of color and psychological scales of color. This leads to a simple description of the three qualities of dimensions of color which are seen by the eye, and to a discussion of the practical advantage both

*Paper presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Toronto, Ont., February, 1930. When this paper is published reference will be given.

to industry and the arts of uniform scales by which each of these three dimensions can be readily visualized and measured.

Rôle of ceramics in architecture.* REXFORD NEWCOMB. Sculpture and painting have often been spoken of as the "handmaids" of the mother art of architecture. True as this may be more certain still is the little-emphasized fact that down through the ages architecture and ceramics have, marching hand in hand, made a triumphant pageant. Used in the oldest masonry building in the world still standing, colored and glazed ceramic materials have had a place in every worthy style of architecture since developed. In every age and clime, the contributions of the potter's art to architecture have been interesting and colorful. This fascinating story should be known to every ceramist.

Training required for work of an architectural colorist.* MARY L. HULL. The work of a colorist in a terra cotta factory includes design of color schemes for building, preparation of detailed instructions for application of colors in the factory and collaboration with various departments. The work requires a thorough art training, including line and mass drawing, painting in oils and water colors. A good course in perspective and a thorough knowledge of the physics of color are essential. Training in ceramic chemistry would be helpful but is not necessary.

Study of cadmium-selenium red.* Led by HENRY MARLEY. The preparation of the cadmium-selenium red using various sources of cadmium sulphur and the powdered selenium metal.

Air brush as it is related to good design.* HAROLD S. NASH. Following the idea that good design in the applied arts capitalizes the natural limitations of the material, a spirit consistent with the use to which the article is to be put, and the process or processes by which it is made, it is proposed to describe some of the inherent possibilities of the air brush that make it a modern tool for modern decoration, and also certain practices that should be avoided.

Colored cement pottery. KATHERINE M. GILLESPIE. *Design*, **31** [8], 152–55 (1930).—Every child should have some experience in modeling and producing. Detailed information regarding materials and processes involved are given. Illustrated. E.B.H.

Ceramic museum in Munich. ANON. *Tonind.-Ztg.*, **53** [93], 1645 (1929).—The museum has 350 rooms and contains everything concerning this industry from the most rudimentary implements to the most up-to-date. There are several models, of kilns and furnaces, one-third their actual size. The display of porcelain is especially fine. Another section contains a splendid collection of Roman ware found in Germany. M.V.K.

Ultramarines. J. HOFFMAN. *Z. anorg. allgem. Chem.*, **183** [1], 37–76 (1929).—A study is presented of the structural and color changes in ultramarines. L.T.B.

Stiegel types of American glassware. HAZEL E. CUMMIN. *Crockery Glass Jour.*, **107** [12], 99–101 (1930).—The history and progress of the Stiegel glassware and also some of the men connected with its progress is discussed. Illustrated from the collection of Geo. S. McKearin. E.P.R.

China and glassware for 1930. ANON. *Pottery, Glass, and Brass Salesman*, **40** [21], 153–54(1929).—(1) Spode's Lowestoft is being shown on stone body with a modern decorative treatment. The decoration is hundreds of years old in the Chinese originals, but Lowestoft made them famous and popular in England and now W. T. Copeland & Co. are reproducing them on stoneware body. (2) Dunbar Flint Glass Corp. has brought out some new shapes in ice-tea and water sets ornamented with the "Silver

*Paper presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Toronto, Ont. February, 1930. When this paper is published reference will be given.

Rose" cutting and embellished with gold encrustations. The new "Brocatelle" line of flat ware was also designed by them. This latter is done in a satin-finish etching carrying a poppy design and is given an iridescent treatment on both the pink and green glass. (3) The W. S. George Pottery Co. has brought out a new dinnerware shape, characterized by square lines, and designed to complement the Derwood shape. (4) The Schumann China Corp. has produced a typical Dresden design known as the "San Luis Rey" pattern done on an ivory body with floral groups and festoons. The colors are shades of red, purple, blue, green, and yellow. (5) Rowland & Marsellus Co. have a new shape in the Devon ware known as the "Florentine." (6) The "Maryland" shape on Furstenberg china by Fred C. Reimer Co. has now been patented. The shape suggests old silver. The flat ware carries indented flutes at the shoulder, with a slight elliptical indentation at the edge. E.P.R.

Decorative glassware. ANON. *Nat. Glass Budget*, **45** [36], 11 (1930); for abstract see *Ceram. Abs.*, **9** [1], 12 (1930). E.P.R.

Making rock crystal. BLANCHE NAYLOR. *Pottery, Glass, and Brass Salesman*, **40** [21], 129–30 (1929).—The making of Swedish glassware began as a natural outcome of favorable conditions, and its progress and development have been carried on through the centuries. In 1909, the first Swedish glassware and rock-crystal ware were brought to the U. S. The colors to be obtained are deep "barley-candy" red, pale green, amber, and golden yellow. These sets come from the Bohlmark factory. "Rock crystal" ware is made from a powdered rock crystal as a silica to produce the finest glass. The process is sufficiently difficult without any additional elaboration. E.P.R.

Opaque glass for interior decoration. ANON. *Diamant*, **51** [7], 126 (1929).—The new opaque glass is vitreous, combines the clearness of glass with the hardness and strength of marble, and can be used for translucent walls, floors, or coverings, for completely fitting out private bath rooms, and as tops for tables, stools, cabinets, and other household equipment. E.J.V.

Modern art windows of enameled glass. A. KEILBLOCK AND R. KEILBLOCK. *Diamant*, **51** [9], 166–67 (1929).—The method of using fusible colored enamels for producing stained glass from white or slightly colored glass which serves as a background is discussed. E.J.V.

Stained glass of Hans Schmitt. THEO MARIA LANDMANN. *Diamant*, **51** [13], 241 (1929).—One of the newer stained glass artists of consequence is Hans Schmitt (Essen). His type of art is discussed and illustrated. E.J.V.

Franz Weitzel, art glass painter. ALBERT. *Diamant*, **51** [8], 142–43 (1929).—A brief sketch of Franz Weitzel of Coburg and his work in stained glass, with four illustrations is presented. E.J.V.

Semiporcelain in new shape. ANON. *Crockery Glass Jour.*, **108** [1], 74 (1930).—The Illinois China Co. is producing a new shape in a semiporcelain body named "The Arlington." E.P.R.

Architectural pottery and tableware at the "Werkbund" exhibition at Breslau. BERDEL. *Tonind.-Ztg.*, **53** [83], 1475–77 (1929).—Description of the exhibition, 1929, at Breslau, Germany. The large number of exhibitors, the variety and coloring of the ware, and the quality of the porcelain contributed greatly to its sucess. M.V.K.

History of French porcelain. ANON. *Christian Sci. Mon.*, **22** [26], 11 (1929).—An exhibition of French china was recently held in Paris at the Pavilion de Marsan in the Louvre. It illustrated the history of French porcelain from its beginnings in the 17th Century to the year 1914. Collectors from many parts of France loaned rare specimens. Limoges and Sèvres sent some of the finest pieces from their museums. A brief historical sketch of French porcelain is given. Illustrated. E.J.V.

Pottery of Vally Wieselthier. RUTH CANFIELD. *Design*, **31** [6], 103–105 (1929).—

The work of Vally Wieselthier from Vienna (now of N. Y.), is commanding large enthusiastic audiences. Garden figures of terra cotta are made in brilliant colors. Of low-fired ware each figure is composed of several sections either skilfully or obviously cemented. Elaborate vases, jars, and bowls show a great deal of originality. Decorations, always brilliant, are modeled on in the plastic state and the color laid over the opaque white glaze of the piece in the form of a fusible glaze or pigment. Descriptions and illustrations are given. E.B.H.

Indian pottery and its value. J. U. TERREL. *Crockery Glass Jour.*, **107** [12], 129 (1930).—In this age of machinery, with modern methods of manufacture changing constantly, the Indians of the Southwest are erroneously believed to be without culture having remained constant in their methods of manufacturing their own peculiar products. One of the chief characteristics of this Indian pottery is that no two pieces are made alike. It is made in the pueblos beside the Rio Grande river with the same method of manufacture as their ancestors used and is as lasting a pottery as any made in the world. The designs and shapes come from objects of nature and their decorations are painted brilliant reds and yellows and dense glossy black. At San Ildefonso, when a piece is ready to be baked it is bathed in a specially prepared dirt which transposes the natural red clay to black by chemical reaction making the piece black all the way through. The design is painted on the red clay in brilliant yellow. The yellow also fades in the reaction and does not retain the luster. The piece after being baked is therefore two-toned, having a black onyx-like gloss and a dull design clearly visible and beautiful. Each Indian tribe has its own distinct method of design and decoration. E.P.R.

Chinese pottery of Han Dynasty. WILLIAM KING. *Studio*, **94** [391], 35–40 (1929).—First Chinese pottery with aesthetic appeal appeared in the 3rd Century B.C. The ware with painted decoration in black and reddish brown was followed by glazed ware, the glazes of green, yellowish brown, and deep brown, probably being the result of trade intercourse with the outer world. Glazed pots buried in earth produced lustrous effects. Hill jars, granary jars, etc., are described and illustrated. E.B.H.

Humor in French ceramics. ANON. *Christian Sci. Mon.*, **22** [32], 6 (1930).—Robj, a French company, is doing an extensive business by introducing humor into ceramics. Amusing figures are utilized as book ends, lamp or pen holders, etc. Illustrated. E.J.V.

PATENTS

Design for plate. CHARLES WEISS. U. S. 80,344, Jan. 14, 1930; FRANK G. HOLMES. U. S. 80,314 and U. S. 80,315, Jan. 14, 1930.

Design for dish. CHARLES LEIGH SEBRING. U. S. 80,191, Dec. 24, 1929.

Design for tumbler. ORIE J. MOSSER. U. S. 80,330, Jan. 14, 1930.

Design for transparent bowl. EDWIN B. GILLINDER. U. S. 80,172, Dec. 24, 1929.

Cement, Lime, and Plaster

The system alumina–lime–water. ANON. Dept. Sci. Ind. Research [London], *Rept. Bldg. Research Board*, No. 58 (1928).—A knowledge of the system, alumina–lime–water, is of importance in determining the processes that ensue during the hydration of Portland and aluminous cements. In the course of the investigation, equilibrium has been approached from three directions by the use of the following types of mixtures: (1) alumina gel-lime-water, (2) sintered tricalcium aluminate-lime-water, (3) supersaturated monocalcium aluminate solution-lime-water; and concordant results in general were obtained. The solubility curves of alumina in lime solutions at 25°C and the limits of stability of the various hydrated aluminates have been determined. The

composition of the various solid phases has been partly elucidated. There appear to be five stable and two unstable solid phases in the system. Of these there are two forms of alumina, one stable and one unstable, one unstable and three stable calcium aluminates, and calcium hydroxide. The crystalline hydrated calcium aluminates which have been identified are $3CaO \cdot Al_2O_3 \cdot xH_2O$, where x is about 10, crystallizes in thin hexagonal plates; $3CaO \cdot Al_2O_3 \cdot yH_2O$, where y is probably 6, crystallizes in a simple cubic form; $zCaO \cdot Al_2O_3 \cdot aH_2O$, where z is about 3.5 or 4, forms crystals so minute as to be hardly discernible with the highest magnification available. At higher temperatures there are considerable changes in the system; the solubility of $Ca(OH)_2$, decreases at 100° C to one-half its value at 25°, and the isotropic aluminate $3CaO \cdot Al_2O_3 \cdot yH_2O$, crystallizing in the cubic system appears to dominate the system. There is also considerable evidence that at the higher temperatures the region of stability of the aluminate of higher lime content and of the compound, $3CaO \cdot Al_2O_3 \cdot xH_2O$, are very limited. W.L.

Studies on fundamental synthesis of calcium aluminates and their hydration. SHOICHIRO NAGAI AND RYUICHI NAITO. *Concrete*, **35** [5], 119 (1929).—$CaO \cdot Al_2O_3$ and $5CaO \cdot 3Al_2O_3$ were synthesized by heating mixtures to different temperatures under 1300°C. E.A.H.

Crystal structure of tricalcium aluminate. F. A. STEELE AND W. P. DAVEY. *Jour. Amer. Chem. Soc.*, **51** [8], 2283–93 (1929); *Rock Prod.*, **32** [24], 77 (1929); for abstract see *Ceram. Abs.*, **9** [1], 15 (1930). W.W.M.

Reactions between colloidal silica and lime. P. JOLIBOIS AND L. CHASSEVENT. *Ciment*, **7**, 318–19 (1929); *Rock Prod.*, **32** [23], 93–94 (1929); see *Ceram. Abs.*, **9** [2], 85 (1930). W.W.M.

Mathematical method of proportioning. JOSEPH A. KITTS. *Concrete*, **35** [5], 33–35 (1929).—A new set of empirical equations for determining the cement and water content of the mix and the fineness modulus of the mixed aggregate based on the averages of a large number of tests is presented. E.A.H.

Cement tests. R. R. COGHLAN. *Concrete*, **35** [5], 101–104 (1929). E.A.H.

Influence of grinding fineness and chemical composition on water requirements of cements. HANS KÜHL. *Tonind.-Ztg.*, **53** [85], 1509–10; [86], 1527–29 (1929).—Experiments made by K. with various kinds of cements indicate a definite relationship between the degree of solidity obtainable and the fineness of grinding as well as the quantity of water added. The highest degree of solidity was obtained with a medium grind and not a fine grind of cement. He found that the solidity of the coarse grind of cement was less affected by an increase in the quantity of water than was the fine grind of cement, but there was a great variation in the solidity ratios. The difference in the solidity of concrete seems to depend on the difference in the granular structure of the cement. Or, the value of a cement lies not necessarily in its fineness but in the regularity of its granular structure. M.V.K.

Technical data concerning the Daignac (France) cement plant. A. STEIGER. *Rev. mat. constr. trav. pub.*, pp. 232–33 (1929); *Rock Prod.*, **32** [23], 93 (1929).—A detailed description is given of the various technical aspects of cement production at this mill. Raw cement mixtures are calculated by the Gruen graphic method to obtain a cement high in tricalcium silicate. The capacity of the rotary kiln (10 ft. in diameter by 197 ft.) is 900 to 1100 bbl. per day. The wet process is used and the slurry contains 35 to 40% water. The kiln is supplied 10% excess air; 75% of the combustion air is preheated in the cooler to 687°F, and the pulverized coal-air mixture enters the kiln at 626°F. Clinker leaves the kiln at 2102°F, and the cooler at 212 to 302°F, thus 80,000 B.t.u. are recovered per 220 lb. clinker. S. gives all necessary data and table for calculations of heat problems on the kiln, and shows that operating the three-com-

partment tube mill below full capacity lowers its efficiency. Slurry mixing tanks are air agitated. W.W.M.

Anhydrite cement and its properties. P. P. BUDNIKOFF. *Zement*, **18**, 31 (1928); *Rock Prod.*, **32** [24], 109 (1929).—B. summarizes the properties of anhydrite cement and presents data on its production. A mixture of sodium bisulphate and copper sulphate is the best catalyzer for the preparation of anhydrite cement. The latter can be regenerated without addition of catalyzers. Mechanical strength of anhydrite cement is decreased by addition of CaO and strength fluctuations over a period of time result from the formation of an unstable complex hydrate. W.W.M.

Slide rule for calculating compounds in Portland cement. L. A. DAHL. *Rock Prod.*, **32** [23], 50–52 (1929).—D. describes the use, construction, and mathematical basis of design of scales, which, when fastened on an ordinary slide rule, can be used to calculate from the chemical analyses of Portland cement and clinker the compounds present when the combination is complete. W.W.M.

Determination of free lime in hydrated Portland cement. ANON. Dept. Sci. Ind. Research [London], *Rept. Bldg. Research Board*, No. 39 (1928).—A modified thermal method seems satisfactory for the determination of free lime in hydrated cements or in concretes containing inert aggregates. When hydrated cement is heated to 370°C the hydrated silicates and aluminates lose their water of hydration; at 550°C calcium hydroxide is decomposed to quicklime, but calcium carbonate is not decomposed at that temperature. A sample of set cement is heated at 370°C for half an hour, then placed in water. The dehydrated silicates and aluminates are rehydrated with a heat effect which may be measured. If a second sample is similarly heated to 550°C and then immersed in water there is produced an additional heat effect due to the slacking of the quicklime present. From this increased heat effect the amount of free lime may be calculated. W.L.

Free lime in Portland cement. S. L. MEYERS. *Rock Prod.*, **32** [24], 76–77 (1929).—M. cites four reasons why the Lerch and Bogue ammonium-acetate method for free lime determinations is unsatisfactory, and describes an improved apparatus and procedure which applied to this method, simplifies and expedites it. Free lime content is an index to the soundness of the clinker, and is important in the calculation of the mineral constituents present. W.W.M.

Gypsum containing anhydrite for retarding set of Portland cement. ANON. *Rock Prod.*, **32** [26], 72 (1929).—Naturally occurring anhydrite if ground sufficiently fine has a rate of solution of the same order of magnitude as that of gypsum of equal fineness. This would indicate that finely ground anhydrite could be used as a retarder. W.W.M.

Constituents of Portland cement clinker. HANS KÜHL. *Tonind.-Ztg.*, **53** [89], 1571–75 (1929).—K. reviews existing theories on the composition of the constituents of Portland cement clinker and points out their defects. He then explains his own theory and analyses, giving the following compositions: alite = tricalciumsilicate + dicalciumaluminate; celite = dicalciumferrite + dicalciumaluminate. These three materials tricalciumsilicate, dicalciumferrite, and dicalciumaluminate, appearing in alternate combination as alite and celite form the ideal Portland cement. M.V.K.

Composition of Portland cement clinker. ERNEST JÄNECKE. *Concrete*, **35** [5], 105–108 (1929).—The best composition of Portland cement clinker has 2% Fe_2O_3, 8% Al_2O_3, 21.3% SiO_2, and 63.7% CaO; see also *Ceram. Abs.*, **8** [10], 709 (1929). E.A.H.

Theory of the hardening of cement. HANS KÜHL. *Tonind.-Ztg.*, **53** [95], 1672–75; [96], 1690–92 (1929).—A critical analysis is made of all existing theories on the hardening of cement. K. agrees with the gel-theory of Michaelis that the hardening of ce-

ment is brought about by the shrinkage of a gelatinous mass, given the conditions necessary for crystallization. The process begins with the formation of a loose gelatinous mass by the action of water on the surface of the cement grains. This mass acts as the first binder of the particles and is hardened by the removal of water. The inner portion of the cement grains, as yet undecomposed, gradually begins to hydrate and form new jelly, absorbing the water needed for this process from the loose gelatinous mass which accordingly begins to shrink and harden. This action is kept up until the cement grains have disintegrated entirely. In the case of cement not so finely ground, this may go on indefinitely. Accompanying this process a chemical change is taking place in the jelly with an increase in the number of polarized particles. At the beginning the jelly is almost optically isotropic but in the course of a year becomes more and more optically active. It can therefore be concluded that crystallization of the amorphous portions takes place. K. states in conclusion that hardened cement mortar, disregarding its insignificant secondary ingredients, is an unstable jelly of dicalciumhydrosilicate, tricalciumhydroaluminate, calciumhydrate, and tricalciumferrite of unknown combination. All these ingredients take years to crystallize. Little is known of the time required for these processes during which the original gelatinous mass is transformed by hydration from an amorphous into a crystalline state. The hydration of the aluminates, silicates, and ferrites takes place everywhere simultaneously and continuously; it is not a hydration of the chemical ingredients of the clinker grain in an orderly succession, but a hydration according to the penetrability of the reaction from the surface to the center of the cement grain. M.V.K.

Magnesium sulphate and cement. P. KREMSER. *Ind. del Cemento*, **8**, 70–74 (1929); *Tonind.-Ztg.*, **53** [92], 1632 (1929).—Magnesium sulphate is a detriment to cement. When it is present a reaction takes place with the formation of gypsum and magnesium hydrate. The latter with the tricalcium aluminate of the cement causes the appearance of the much-feared cement bacillus with a great increase in volume. To find out the effect of $MgSO_4$, prismatic specimens of pure cement and compositions of one part cement and 3 parts of sand were made and after storing 24 hrs. in damp air were transferred to a 1% solution $MgSO_4$, which was often replenished. After one year the sand mixture had quite disintegrated while the specimens of pure cement were more resistant and showed only schistose exfoliations. The difference is traced back to the different densities and exterior conditions of the specimens. Two ways of reducing the injurious effect of $MgSO_4$ on small masses can be given: (1) painting, and (2) immunizing. The first method gives only a conditional protection as with the appearance of leaks and cracks, the paint tends to peel off making way for the penetration of the corrosive solution. The second method consists of saturating mortar or concrete with a preservative. This preservative, a solution of Sika (1:12) as a binding liquid, makes the materials so resistant that even after two years of storing no bad effects appear. M.V.K.

Experiments for determining properties of cements with different consistencies of mortar and concrete. H. RICHARZ. *Tonind.-Ztg.*, **53** [92], 1619–21; [93], 1636–38; [94], 1658–60 (1929).—An investigation of various kinds of Portland cements and their behavior when mixed with three different consistencies of concrete: liquid, less liquid or soft, and thick. Several self-evident facts were confirmed. The degree of solidity attained by the liquid and soft mixtures (proportion 1:5, 1:4, 1:3) never reached that of the thick (1:7). With the addition of water, or the addition of cement, changes in the consistency of liquid or soft preparations can be effected and the degree of solidity attainable, altered. M.V.K.

Process for burning cement. ANON. *Zement*, **18**, 26 (1929); *Rock Prod.*, **32** [24], 110 (1929).—One or more nozzles arranged in a semicircle, at the discharge or

upper end of the kiln, feed the raw mix or slurry in a fine spray into the fire. The kiln lining is thus protected against the high temperatures. W.W.M.

Effect of storage on cements. HAEGERMANN. *Zement*, **18**, 34 (1929); *Rock Prod.*, **32** [25], 92 (1929).—H. tested 5 ordinary and 8 "high grade" Portland cements, stored in paper sacks in a brick-walled, wooden-roofed shed. A door in the shed was open days. Tests were made after 2, 4, 9, and 18 months storage. The decrease in strength was relatively less for "high grade" cement than for ordinary cement; the 3-day strengths were affected more than the 28-day strengths in all cases, and the compressive strength more than the tensile strength. The "high grade" cements showed little change in two months storage, but 3-day compressive strength decreased 8% in 4 months and 21% in 9 months. After 9 months, 7 "high grade" cements still complied with requirements, and after 18 months only 2 were "high grade." The sets were retarded by storage up to 9 months for the "high grade," and 2 years for the ordinary cement, after which time they became quicker again. W.W.M.

Packing of cement. HEINRICH LUFTCHITZ. *Tonind.-Ztg.*, **53** [84], 1495–97 (1929).—L. recommends that the cement be exposed to the passage of dry air during packing and when removed from the sacks it should be aired for at least a half day. M.V.K.

Cement reference laboratory tolerances. ANON. *Rock Prod.*, **32** [23], 67 (1929).—Proposed tolerances on cement testing apparatus are given. W.W.M.

Notes on plaster of Paris. S. M. MARATHE AND A. D. JOSHI. *Rock Prod.*, **32** [24], 81 (1929); for abstract see *Ceram. Abs.*, **8** [12], 863 (1929). W.W.M.

Manufacture of lime and cement from gypsum. OTTO FR. HONUS. *Zement*, **18**, 37 (1929); *Rock Prod.*, **32** [24], 78–81 (1929).—A review of European process patents including methods of extraction of lime from gypsum, manufacture of cement using gypsum instead of limestone, with H_2SO_4 as a by-product, and production of aluminous cements without the use of expensive bauxites. W.W.M.

Retarders for gypsum plaster. JOSEPH ROSSMAN. *Rock Prod.*, **32** [23], 55–58 (1929).—A digest of U. S. patent literature, covering the period from 1868 to 1920, including 66 patents. For previous survey on this subject see *Ceram. Abs.*, **8** [12], 864 (1929). W.W.M.

Gypsum molds. ANON. *Tonind.-Ztg.*, **53** [80], 1429–30 (1929).—Among the many uses of gypsum in ceramics is that of the making of press molds for roof tile, ridge tile, terra cotta, clay models, porcelain, and other more delicate ware. It is well suited to this purpose because, unlike metal molds, it can be easily separated from wet clay and its capacity to absorb water causes the clay mass to dry and shrink sufficiently to facilitate its removal from the mold. Directions for making, pressing, or casting the various types of molds are given. M.V.K.

New molding plaster of high strength. ANON. *Rev. mat. constr. trav. pub.*, No. 242, pp. 235–36B (1929).—The mixing water used with ordinary plaster is equal to 65% of the weight of the dry plaster. The new plaster requires only 45% and gives a product with double the strength (tensile) of ordinary plaster. In special cases 35% may be used and the strength is $2^1/_2$ times that of ordinary plaster. The product is very dense and shows greater resistance to the solvent action of water. A.J.M.

Substitute for the compression test of concrete. G. J. GRUSENAUER. *Eng. News Rec.*, **103**, 846 (1929).—G. describes a method of analyzing concrete while yet in its plastic condition to check its actual composition against the contract specifications. The method consists in taking a weighed quantity of concrete and washing out the cement to separate it from the sand and gravel. The cement, sand, and gravel are then dried and weighed separately. The water originally present in the mix is determined by difference. From these data the composition of the mix can be reconstructed and compared with the specification mix. This method gives information regarding

the quality of the mix within a few hours instead of waiting for 28-day strength tests. W.L.

Oil-mixed concrete. H. L. KAUFFMAN. *Concrete*, **35** [5], 35 (1929).—Concrete mixed with oil takes longer to set hard but increase in strength is nearly as rapid in oil-mixed material as in plain concrete. The use of oil does not make the concrete impervious to heavy water pressure but it does make it practically nonabsorbent under low heads. Use of oil decreases somewhat the compressive strength of mortar and concrete, but not seriously. Oil must not exceed 10% of the weight of the concrete. E.A.H.

Heat balance in cement firing in vertical and rotary kilns. G. SOZETTI. *Ind. del Cemento*, **2**, 9 (1929); *Tonind.-Ztg.*, **53** [92], 1632 (1929).—S. calculates the quantity of heat necessary for firing cement and heat lost uselessly during firing in two cases. For vertical kilns with a total loss of 30%, the principal loss is in waste gases and the penetrability of the kiln walls. The great loss of heat due to radiation can be reduced, if not altogether prevented, by proper construction of the kiln. In rotary kilns which have a 45% loss of heat, the greatest loss is caused by the evaporation of the water of the wet mass. Recently great progress has been made in the effort to make use of the waste gases. M.V.K.

Heat transfer in rotary kiln burning Portland cement clinker. R. D. PIKE. *Ind. Eng. Chem.*, **21** [3], 230–34 (1929).—P. discusses the heat-transfer relations existing in a rotary kiln fusing Portland cement clinker and their relation to rotary-kiln design. Calculations involved and explanatory charts are shown. See also *Ceram. Abs.*, **8** [7], 482 (1929). R.G.M.

Fuel economy in rotary kiln burning Portland cement clinker. R. D. PIKE. *Ind. Eng. Chem.*, **21** [4], 307–10 (1929); for abstract see *Ceram. Abs.*, **8** [4], 250 (1929). R.G.M.

New Italian cement specifications. ANON. *Beton Eisen*, 19 (1929); *Rock Prod.*, **32** [25], 92 (1929).—Amendments of April 4, 1929, to the Italian Cement Specifications of 1927 are given. W.W.M.

China's cement industry. A. LEONHARD. *Zement*, **18**, 2 (1929); *Rock Prod.*, **32** [25], 94 (1929).—Importation of cement in China has decreased in recent years. Japan is the chief exporter to China. Seventy per cent of cement produced in China is by Chinese-owned and financed plants. L. cites three Chinese plants and their capacities. W.W.M.

Uruguayan cement specifications. ANON. *Zement*, **18**, 37 (1929); *Rock Prod.*, **32** [25], 92 (1929).—New specifications for Portland cement imported into Uruguay are given. W.W.M.

Spray process of slurry feed. S. J. M. AULD. *Cement and Cement Mfg.*, Nov. (1929); *Rock Prod.*, **32** [26], 70–72 (1929).—The wet process has many advantages over the dry, but a decrease of 10 to 15% in output accompanies the change from dry to wet feed of a kiln of given fuel capacity under the older systems of slurry feed. Spraying the slurry into the kiln results in optimum conditions of heat transfer by exposing the largest possible surface to hot gases. The main features of the Rigby process, which is being developed by the Industrial Driers, Ltd., of London are (1) the spraying of the slurry down the length of the kiln in counterflow to the ascending hot gases; (2) use of directional control of the spray so that evaporation is so far completed before the slurry touches the walls that there is little or no adherence, and therefore a reduced tendency to build up slurry rings; and (3) the use of a slurry lute in the smoke chamber for the collection of dried or partially dried slurry deposited from the spray or carried over from the kiln. Eighty per cent of the clinker from this method will pass a $^1/_8$-in. screen. One or more nozzles may be used for spraying the slurry.

The greatest wear is on the nozzles, which are easily and cheaply replaced. The method reduces fuel consumption per weight of cement produced by 15 to 20%, and output per kiln by 20 to 30%. Installation and maintenance costs are relatively small. The Rigby process makes possible the use of shorter kilns, allays dust troubles, and reduces wear on kiln linings. W.W.M.

Why cement specimens crack and scale in cold water testing. HAEGERMANN. *Zement*, **18**, 36 (1929); *Rock Prod.*, **32** [24], 110 (1929).—It has been assumed that cracking and scaling of the surface layer of cement specimens prepared for determining volume consistency in cold-water testing is due to or indicative of blowing. H. arrived at different conclusions in testing five normal setting cements. He found that slight cracking and scaling occurs if the pats are immersed in water before or shortly after they start to set; pats immersed during the setting process do not crack or scale unless immersed shortly after termination of the set; pats immersed several hours after setting do not crack or scale. These results are explained by the formation, during preparation, of an aqueous layer on the surface of the pat containing hydrate of lime and soluble salts. This layer solidifies quicker than the mortar beneath it, due to the influence of carbonic acid in the air. W.W.M.

BOOK

Experiments on Concrete Aggregate Materials to Determine Structure and Linear Expansion Changes with Temperatures up to 1200°C. K. ENDELL. Published by Ernst and Son, Berlin. Reviewed in *Tonind.-Ztg.*, **53** [82], 1472 (1929).—Experiments concerned the injurious effects of heat on reënforced concrete. The linear expansion of aggregate materials for pure hardened Portland cement and Portland cement mortar at temperatures up to 1200°C were measured and structural changes noted. The following aggregate materials were used: stone containing quartz, limestone, basalt, diabase, high kiln slag, and mansfield-copper slag. The high kiln slag and mortar made from it showed the best results. Special mention is made of photographs and slides of the substances which show clearly the state of the aggregates and mortar. M.V.K.

PATENTS

Cements. H. C. BADDER. Brit. 320,597, Dec. 11, 1929. Colored hydraulic cements are made by fusing a pure base of Portland cement or of aluminous cement, etc., together with metallic oxides, carbonates, or other salts. A small proportion of fluxing material may also be added. The raw materials and coloring matter are very finely ground, *e.g.*, to pass a 200-mesh sieve. The fused cement is run into molds and subsequently ground. Examples of coloring matter are ferrous and ferric oxides, oxides of copper and cobalt, salts of iron, copper, manganese, cobalt, and chromium, and earth pigments such as ocher, bole, sepia, and brown umber. In some cases a proportion of finely ground metal may be added to overcome the effects of the caustic lime on the colors.

Air-tight discharge for shaft kilns and coolers. ARNO ANDREAS. Ger. 481,058, 1928; *Rock Prod.*, **32** [25], 93 (1929).—The individual discharge openings are closed air tight by means of two or more gates, one after the other, although they may be closed simultaneously. A more effective seal against air circulation is thus obtained. W.W.M.

Enamels

Determinations of alkalis in vitreous enamel. ROBERT B. SCHAAL. *Jour. Amer. Ceram. Soc.*, **13** [2], 113–25 (1930).—Sodium and potassium comprise from 5 to 25% of the total composition of vitreous enamels. The other 75% is comprised of a wider variety of other elements than is found usually in materials which are analyzed for their

alkali content. No less than twenty-five oxides are used commonly in enamel glass, and often fifteen of these are in a single enamel. The task of removing all interfering elements from the alkalis is an analytical problem of more than ordinary difficulty. The process is necessarily long and tedious. It calls for the most exact attention to detail and the most careful manipulation. S. tells of attempts to use the usual methods for determination of alkalis in vitreous enamel, and also the procedures found to be most useful and accurate for all classes of enamels.

Effect of furnace gases upon glass enamels. E. E. GEISINGER AND K. BERLINGHOF. *Jour. Amer. Ceram. Soc.*, **13** [2], 126–42 (1930).—The effect of various fuel gases of products of combustion and pressures on bonding of ground coat, physical condition and gloss of the enamel were studied under laboratory controlled conditions to determine the comparative results of firing in open and muffle furnaces and with fuel of different sorts. The benefits of recuperation are shown to be in complete combustion rather than in excess oxygen. Very hot diluted air would increase the efficiency of either oil or gas burners and produce better enamels.

Costs savings in continuous furnaces.* C. A. DUTTON. The history of industry in general has indicated that productivity increases with capital investment. The capital investment of the continuous enameling furnace for wet process depends upon its capacity and is the equivalent of between the two- and six-box type enameling furnace. The continuous furnace is replacing the box-type furnace because of its savings in labor, fuel, and floor space, its indirect savings in quality, production, and cost control, as well as its simplified supervision. Direct labor savings of 60% and fuel savings of 30% are not uncommon and installations show $100.00 a day direct savings due to continuous furnaces. The continuous furnace has made further savings possible by the application of the continuous principle to other enamel shop operations, continuous spraying for example.

Experiences with fused alumina and silicon carbide refractories in enameling industry.* ROBERT KIRKPATRICK. The remarkable progress in the enameling industry during the past ten years has resulted in improved enameling furnace refractories. Many things regarding furnace construction have been learned from actual experience. In particular the need of super-refractory materials such as the well-known electric furnace products, silicon carbide, and fused alumina, has been proved. Both of these materials are crystalline in structure; they are formed at high temperatures; they can be ceramically bonded, and formed into shapes for various types of enameling furnace muffles. The actual relative value of these two electric furnace products as refractories is defined by their inherent physical and chemical characteristics. The tendency of silicon carbide to oxidize at more than one range of temperature has sometimes been the cause of furnace troubles. This oxidation produces a change in physical characteristics which often results in a lack of uniform service in enameling furnace muffles, and finally the destruction of the muffle itself. Fused alumina is a very stable oxide which retains its original properties, thereby increasing the probability of uniform service throughout its life. It does not decompose, or are its physical properties changed through chemical action. Enameling plant experience indicates that more general satisfactory service has been obtained from fused alumina than from silicon carbide.

Comparison of results obtained with impact machine.* R. H. TURK. A description is given of the impact machine having a pendulum of rigid design. An instantaneous mechanical release is used eliminating the human element. Results of tests with this machine are given showing a unique consistency.

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*Paper presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Toronto, Ont., February, 1930. When this paper is published reference will be given.

Results obtained during study of foundry practices.* WM. BOGENSCHUTZ AND H. G. WOLFRAM. Constant observations of foundry practice in the manufacture of gray iron castings for enameling, over a period of eighteen months have permitted recommendations which when put into use have greatly improved the quality of the finished product. Results and analyses are given which have been obtained in a number of foundries and enameling plants.

Impurities in commercial feldspars often overlooked by enamelers.* JAMES R. CRANDALL. The purpose of this paper is to point out the necessity for careful selection and constant supervision of all raw materials, together with simple tests which the enameler may apply to such materials to insure a uniform product free from objectionable impurities.

Observations of causes for inconsistent results in commercial fineness tests of porcelain enamels.* H. G. WOLFRAM. Results are given of commercial tests showing inconsistencies. As investigation proved these to be due to careless manipulation, clogging of screen openings, variations in size of openings in the original cloth as manufactured and distortion of mesh in fastening the cloth to the frame.

Proper method of cooling continuous furnaces.* PAUL V. BLACKBURN. B. stresses the importance of adequate firing tools for handling the various shapes which are enameled in continuous furnaces. The maximum efficiency of a continuous furnace can only be realized when the conveyer chain is equipped with tools which permit uniform loading throughout its entire length with enough ware to utilize fully the heating capacity of the furnace. Materials and principles of design are considered. Specific tools and racks suitable for various sheet iron and cast iron parts are illustrated.

Development of acid-resisting white sheet steel enamels.* A. I. ANDREWS. Many of the commercial sheet steel enamels are readily attached by such weak acid solutions as fruit juices and are stained by milk and by some city waters. This paper gives the development of a number of acid-resisting enamels. It shows that acid resistance is the result of the right combinations of raw materials rather than the presence or absence of any particular constituent. Acid resistance is not affected by fineness of grinding or by the smelting conditions if the enamel is properly smelted. Mill additions of clay reduce the acid resistance, but opacifiers added in this manner have no effect. Temperature and time of firing may or may not affect the acid resistance depending on the composition of the enamel.

Acid-resisting white dry-process cast-iron enameling.* A. I. ANDREWS. Beginning with simple compositions containing only those constituents necessary to make a glass, additions were systematically made in the development and study of acid resisting enamels. It was found that the acid resistance depends on the proper combination of constituents rather than the presence or absence of any particular material. It was shown that all fluorine compounds are detrimental to acid resistance but experience shows that some form of fluorine is necessary to obtain good quality opacity. Smelting (if properly done), milling, and burning have practically no effect on the acid resistance.

Progress report on effect of furnace gases on quality of enamels.* A. I. ANDREWS AND E. A. HERTZEL. The appearance of sheet enamels fired in atmospheres of nitrogen, carbon dioxide, sulphur dioxide, and Urbana city gas, has been determined. A study of the effect of variations in composition of sheet steel ground coats and sheet steel cover coats on their resistance to attack by sulphur gases has been made. Plans for future work on the problem are outlined.

Study of soluble salts in enamels.* R. D. COOKE. A study of the effects of a

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number of soluble salts on one type of sheet steel enamel. The factors affecting the quantities and nature of the salts normally appearing in the enamelware were observed. The effects of these salts together with those of a number of added salts were noted from the standpoint of set-up of the enamel, rusting of the iron, and appearance of the fired enamel.

Effect of furnace gases on cover coat enamels.* G. H. MCINTYRE. Test strips $1^3/_4$ by 5 inches were enameled under standard conditions with a commercial sheet iron ground. The white cover coat enamel was fired in a quartz tube muffle, in which the atmosphere and temperature could be carefully controlled. The atmosphere was varied by passing such gases as sulphur dioxide, illuminating gas and carbon dioxide through the quartz muffle during the firing of the enamel. Varying concentrations from 100% of the gas down to less than 1% mixed with air were used. Photographs of the fired samples are included.

Opacifying effect of some fluorides in enamel mill additions.* R. M. PEARCE AND R. M. KING. This paper describes the results of a study of the effect of barium fluoride, zinc fluoride, and magnesium titanium fluoride on enamels when added in the mill. These fluorides were used with high silica, high borax, high lead oxide, and high antimony oxide enamels. The effect of these fluorides upon opacity, and the creation of such defects as crawling and crazing are shown by triaxial diagrams and photographs.

Relation of metal cleaning in perfect enameling.* EDWARD L. MCILHENNY. The fundamentals of metal cleaning and the application of those fundamentals in the pickle room of the enameling shop are considered in this paper. The different types of oils ordinarily found on ware to be enameled which have been used either for flushing or drawing purposes are also discussed. Mention is made of the different methods of cleaning available to the trade with particular emphasis laid on the methods and precautions to be taken when the cleaning medium is an alkaline solution. Hints on making up a tank, keeping the proper concentration, methods for determining the point at which a solution has ceased to function properly, etc., are included. Various troubles encountered in the enameling shop which are the causes of rejected ware are described and a relationship drawn between those troubles and the foregoing cleaning operations.

Practical experience in enameling inside of containers with a small opening.* VICTOR R. BARTH. To obtain a vacuum between inner and outer shell the parts of a vacuum bottle are electrically welded; therefore, the bottom could not be enameled separately. A tight enamel job was obtained by blowing out all the hydrogen gases during the burning of the ground coat. The modern kitchen has cooking utensils, sink, washing machine, table, stool, refrigerator, stove, wall, etc., enameled, why not an enameled water boiler?

Summary of experimental work with Lindemann-Danielson cross-bending test machine.* C. J. KINZIE AND G. A. PLUNKETT. The effect of several variables such as enamel type, thickness of coating, fineness of milling, etc. are discussed and results submitted. A special application of this machine is described in which it has been used in studies of effect of dry film strength upon tearing in vitreous enamels.

Development and use of a simple consistency pipette for use in adjustment and control of enamel slips.* C. J. KINZIE AND C. H. COMMONS. A metal consistency pipette is described and some details relative to its development and use are given.

Opacity in terms of colors of enameled objects.* R. E. STARK. Matching of colors is a most difficult task especially when the judgment of different eyes enters the equation. This paper has been prepared with the idea of constructive criticism con-

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cerning so-called "opacity" of an enamel and suggestions advanced as to how a "standard" for color comparisons can be made, especially in regard to white enamels.

Discussion: Methods of determining effects of ingredients upon properties of enamels.* Led by W. N. HARRISON. The assumption that the addition of a given ingredient to an enamel, of any base composition, causes a change in properties which is directly proportional to the percentage of material added, apparently has to be discarded. In the case of expansivity this assumption is near enough the truth to permit some other valuable calculations by the "factor" method. In the case of some other properties, however, and especially with certain ingredients, the factor varies greatly with the composition of the base glass. Even that variation in composition of the base glass which is caused by adding the variable constituent under study is sometimes sufficient to markedly change the magnitude of the effect caused by introducing an additional unit of the same variable. Possible means of approaching the problem and analyzing results obtained in a study of the effect of different variables will be discussed. Also means of measuring fusibility, elasticity, expansivity, tensile strength, and other properties will be mentioned.

Design of enamel smelting furnace.* R. D. COOKE. Experiments with the construction of an open-hearth smelter are described which resulted in the design shown. The walls were made thin and the bottom supported on beams exposing the entire outside of the hearth to the air.

Modern sandblasting.* CHAS. BOULTMAN. Treating surfaces by sandblast process preparatory to covering with vitreous enamels, galvanizing, parkerizing, lacquering, painting, or electroplating is rapidly superseding other methods of surface treatment. The sandblast process from its primitive inception which was surrounded by unsanitary operating conditions with high production costs has been developed to a point where with modern facilities, production costs have been substantially reduced and operating conditions made sanitary. Only with applied research and practical experience of years has it been possible to determine the conditions necessary to sandblast the maximum of work with minimum of cost under really hygienic operating conditions. To get the most out of sandblast process, it is necessary to analyze thoroughly every influence that contributes to production, cost, and operating conditions and then coördinate them to create an ideal condition. Statistics prove that where "ideal conditions" exist, production rate is higher, costs lower, and operating conditions are best. The contributing influences involved in the sandblast process are the abrasive equipment design, compressed air, ventilation, kind of work and method of handling same, and the human element. The subsequent subject matter discusses each of these influences and their coördination.

Construction of refrigerator linings.* C. H. WOLFF. During cooling, compression stresses are built up in the enamel coating while the iron itself is under tensile strain. The compression forces from the three sides meet at right angles at the corners of the linings and cause chipping. Mechanically reënforcing these corners helped little. By notching the flanges, welding in a small fillet, and welding an angle strip underneath the flange at the corner, the forces at work were reduced enough to overcome the chipping.

New industrial uses of rubber.* H. E. FRITZ. A discussion of rubber-lined steel tanks for the purpose of storing and transporting muriatic acid and other corrosives; also, rubber-lined steel pipe, valves, and fittings for the transportation of corrosives is given. The rubber cutless bearing was also discussed.

Raw and white ground coats.* A. MALINOVSZKY. M. discusses the possibility of

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using the mineral lepidolite as a ground coat for enamel. Analysis of several samples of lepidolite are given, their refractoriness and expansion values calculated. Being high in Al_2O_3 and containing no B_2O_3 precludes the use of lepidolite in any essential quantities. Lithium oxide of which lepidolite contains about 4% does not aid in adhesion of the ground coat to cast iron. M. also discusses patented ground coats comprised of various materials and minerals. The literature is reviewed and examples of good and defective ground coats are discussed using composition data and microphotographs to illustrate the essentials for good ground coat adherence.

Physical tests: Method for determination of firing range of vitreous enamels.* C. J. KINZIE. Several methods for making burning range studies in case of wet-process enamels are described. The methods used in producing enamel deposits of predetermined weights are given. The use of these methods has shown that enamels used in wet-process enameling of metal vary widely in action under various conditions of heat and a general discussion of the subject is included.

Ball or pebble milling in ceramic industry.* H. F. KLEINFELDT. This paper deals with the general principles of efficient grinding in pebble mills, taking into consideration the correct number of revolutions, the selection of the proper size of grinding media for the particular work to be accomplished, the relationship between pebble size and the consistency of the product in wet grinding, the proper charging capacity of mills based on their total volume, and the various improvements in design that have been made in recent years.

Enameling sheet and cast iron. I. Preparation of frit. II. Preparation of metal. ANON. *Jour. usines gaz.*, **53**, No. 17 [Supp.], pp. 9–16 (1929).—The equipment used, the rôle of the various components of the enamel and the importance of oxidizing and reducing conditions in the furnaces are described and illustrated. (*C.A.*)

Corrosion: a problem in protective coatings. F. N. SPELLER. *Ind. Eng. Chem.*, **21** [5], 506–10 (1929).—S. discusses the comparative resistance to corrosion of various metals and protective coatings which may be used to increase the resistance.

R.G.M.

Borax in ground coats. HAROLD WOLFRAM. *Amer. Enzmeler*, **2** [11], 8–16 (1930).—When "setting up" of the ground coat is desired borax is used at the tub, or it can be added in amounts up to 1% in milling if used immediately after grinding. If not used immediately, the borax will crystallize out, reducing the setting-up action, and causing humps. Many plants prefer to "set" the ground coat at the dipping tub, thus making possible the very important aging of the enamel. Though some advocate the use of enamel in larger quantities as a "cure-all" for enameling troubles, if used in amounts over 2%, the fired parts become spongy, and succeeding coats are apt to blister.

J.N.U., JR.

Jumping of enamel. ANON. *Amer. Enameler*, **2** [11], 7–8 (1930).—The difficulties of "jumping" of the first coat of enamel due to plant conditions are discussed. The importance of clean dry castings, is stressed, and also the need for a perfectly dry first coat before the second coat is applied. J.N.U., JR.

Cutting and applying stencils for porcelain enamel. GUSTAV SCHWARTZ. *Amer. Enameler*, **2** [11], 3–6 (1930).—Two methods of cutting stencils are: (1) letters cut out, and rest of stencil left as a whole, and (2) letters left solid, rest cut out. Draw the stencil desired. Cover zinc plate with coating of asphalt, then of tin foil. Trace the letters onto the foil. Remove the cut-out parts of foil, dip plate into a kerosene bath, which removes the asphalt from exposed portions. Submerge plate in 18% solution muriatic acid. When zinc has been eaten away, plunge into pure water. Then

*Paper presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Toronto, Ont., February, 1930. When this paper is published reference will be given.

wash off remainder of asphalt, and file letters smooth. For each sign, two stencils are made with part of each letter on each stencil, so that they will overlap to form the complete letters. Each stencil will last for about 1000 brushings. When only very few brushings are needed, the stencil can be cut out of paper oiled with linseed oil. J.N.U., Jr.

Use of steel abrasive in line with present day practice of enameling plant hygiene and efficiency. Charles Boultman. *Amer. Enameler*, **2** [10], 6–7 (1929).—The line through which compressed air and abrasive pass should have a uniform cross-section for several reasons. Moisture in the compressed air causes trouble. Air must therefore be kept cool. A procedure and apparatus for removing moisture is described. For previous abstracts see *Ceram. Abs.*, **9** [2], 87 (1930). J.N.U., Jr.

Stove making. Pat Dwyer. *Foundry*, **57**, 21 (1929).—A general description of the foundry practice in making stove castings which are to be enameled is given. O.E.M.

Continuous enameling system. Anon. *Ceram. Ind.*, **14** [1], 40–45 (1930).—The old process at the Coonley Mfg. Co., Cicero, Ill., has been replaced by a continuous system of enamel application, drying and firing, the heart of which is an improved type of Beemack continuous furnace, the whole system making a complete enamel shop in itself. As a result of this evolution, a total of 116,000 pieces of ware have been finished in a day from the black shapes, a 550% increase in production with a decrease in labor from 300 to 185 people. Production per man increased from 60 pieces or less to 627 pieces daily, an increase in productivity of 1045%. In addition, a clear, roomy shop is in evidence and the working conditions have been improved. Two and one-half hours after the ware leaves the pickling room, it is ready for shipment. With these facilities, customers may have 24-hr. service. F.P.H.

Heat and corrosion resistant alloys. T. H. Nelson. *Iron Age*, **123** [17], 1139–42 (1929).—A description of stainless steel, what it is, and how it was discovered is given. Analyses and properties of the three chief types are given. Chrome irons for structures are mentioned. E.C.C.

Acids used in galvanizing work. Heinz Bablik. *Iron Age*, **123** [13], 879–80 (1929).—A résumé of the pickling process, giving formulas and outlining the merits of HCl as a pickling agent as compared with H_2SO_4. E.C.C.

Pickling principles in galvanizing. W. G. Imhoff. *Iron Age*, **123** [15], 957–59 (1929).—Details and data of pickling experiments on sheet steel for galvanizing are given. E.C.C.

Well-designed enameling plant. Anon. *Iron Age*, **123** [15], 1016–18 (1929).—Plant of the Toledo Porcelain Enamel Products Co. (Toledo, Ohio) is described in detail. Special handling of castings, close control of enamels and firing, and cleanliness are outstanding features of this plant. E.C.C.

Firing vitreous enamels electrically. Anon. *Iron Age*, **124** [24], 1581 (1929).—A continuous conveyer-type electric furnace for firing vitreous enamels on kitchenware is used by the Republic Enameling and Stamping Co. (Canton, Ohio). It is a 450-kw., 220-v., 3-phase, General Electric Co. furnace with an output of 30,000 to 34,000 pieces of enamel kitchenware or 15 to 17 T. in 23 hrs. It operates at 3 to 18 ft. per min. and at 1680 to 1700°F. E.C.C.

Fuels for enameling furnace. E. A. Hertzell. *Amer. Enameler*, **2** [10], 8–9 (1929).—No comparisons can be based on production as there are too many other factors involved. The ideal fuel would be one cheap per B.t.u., uniform in quality, easily available, needing no expensive apparatus, no storage space, giving clean furnace condition, and possible of temperature control. (1) The advantage of coal is its cheapness; it is not easily controlled, is dirty, and requires a large storage space. (2) Fuel oil is second to coal in cost per B.t.u., is available, and requires little storage costs

although costly equipment is necessary for its combustion. (3) Gas costs more in most localities than coal or oil. Natural gas is cheapest and most efficient as it burns completely and cleanly, and is easily handled. Uniform temperature and atmosphere can be easily maintained and no storage space is required. Producer gas has other advantages, but larger floor space is needed for its production. (4) Electricity costs the most per B.t.u., but produces clean heat in an atmosphere free from undesirable gases. Furnace construction is simplified and heating is more efficient as no muffle is necessary. Costs for replacements are minimum. J.N.U., JR.

Glass

Colored glass for technical and decorative purposes.* H. P. GAGE. The greatest volume of colored glass for technical purposes is used by railroads and subject to the specifications of the American Railway Association, Signal Section. Glass for lighthouses, traffic signaling, aviation, theater, and floodlighting must in general conform to specifications of similar nature but modified to meet the particular requirements of service. A few color filters are used in scientific instruments and investigations subject to special requirements. Decorative glassware including illuminating glassware uses glass colors whose requirements are the exact opposite in many cases to those of the A.R.A. specifications. It is hoped to exhibit samples of both technical and decorative colored glass.

Electrical methods for determining moisture.* E. F. BURTON. The main feature of the paper is an experimental demonstration of a new adaptation of an oscillatory circuit devised by B. and Arnold Pitt. The introduction of samples of various substances into the circuit has been found to give a change in plate circuit which is specifically related to the electrical properties of the substance used. Whether the effect is due entirely to electrical conductivity or partly due to dielectric constant change is a moot question. The results of experiments carried out on glass rods, powdered glass, and sand are presented.

Use of polariscope in glass industry.* FRANK W. PRESTON. The action of polarized light as a means for detecting strains in glass is interpreted along two distinct lines, one a simple mathematical treatment of the resolution of simple harmonic vibrations; the other by means of physical analogies. The purpose is to give a presentation which can be followed without any mathematical training and at the same time give a slightly more complex discussion for the more advanced technologist. Various types of polariscopes for detecting and measuring strain are discussed.

Corrosion of tank blocks by opal glass.* C. J. UHRMANN AND S. M. SLATER. The manufacture of opal glass in day tanks has made it necessary to study the corrosion of tank blocks. Opacifiers have to be used in larger quantities than in batches for opal glasses melted in covered pots because of the loss of density due to higher melting temperatures and shorter melting times, and exposure of batch to reactions from the direct flame heat. Experiments have been conducted to ascertain the factors which will allow the use of the lowest amount of opacifiers, the shortest practical melting time with the highest practical melting temperature, and also to minimize the corrosion of the bottom blocks of tanks by application of a cooling system; furthermore, prevention of separation of batch by practising certain "filling-in" methods of the batch, and as a final result to reduce block stones in the glass. The experiments have resulted in the successful operation of day tanks for opal glass, and in prolonging the life of the

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tanks and have made possible the manufacture of thin blown dense opal glasses of almost as good a quality from tanks as can be produced in pots.

Discussion: Opacifiers for glass.* Led by A. SILVERMAN. The discussion will include the use of fluorspar, cryolite, sodium fluoride, sodium silico-fluoride, feldspars, magnesium silicate, zirconium oxide, lepidolite, alumina, china clay, bone ash, etc., in lime, lead, and zinc glasses.

Beryllium glass. II. Potassium beryllium silicate.* A. SILVERMAN AND CHI FANG LAI. Part of this subject included the sodium beryllium silicates, showing areas for good glass and the properties of glasses of various compositions. The second paper included a triaxial diagram for the potash series. This contains two good glass areas in contrast with a single area in the soda series. One area is in the region of low beryllia and high silica; the other in the region of high beryllia and low silica. The latter contains the better glasses. Areas are also shown in which the tendency to increase silica produces opalescence while that toward an increase of beryllium promotes divitrification. Great difficulty has been experienced in obtaining pure beryllium oxide. Material that was supposedly pure contained as much as 20% of moisture. Difficulty has been encountered also through such impurities as the oxides of iron and manganese. Optical data are not yet available. As was the case with the sodium beryllium silicates, so here again the announcement is the first of the potassium-beryllium glasses, to the best knowledge of the authors.

Influence of chemical composition on refractive index, softening point, and density of soda-lime glasses.* J. W. GILL AND W. C. RUECKEL. Nineteen soda-lime glasses covering the commercial field were prepared, melted, and fined for 2 hours. The chemical composition of the raw materials was determined by usual analytical methods; the refractive index was determined by an Abbé refractometer, density, by the normal suspension method, and softening point by the Littleton method with the furnace as specified in *Jour. Amer. Ceram. Soc.*, **10** [4], 259–63 (1927). The data indicate the following points: (1) When the silica was kept constant, by increasing the lime (dolomite lime) at the expense of soda an increase of 11 to 12°C per 1% increase was obtained. Likewise the density increases 0.004 and the refractive index 0.0015 per 1% increase of lime. (2) When the soda was kept constant the softening point was practically constant. The density decreases 0.011 and the refractive index 0.0030 per 1% increase of silica at the expense of lime. (3) When the lime was kept constant the increase in softening point per 1% increase in silica varied as follows: 5% lime 21°C, 8% lime 17°C, 10% lime 15°C, and 12% lime 12°C. The density decreased 0.008 and the refractive index 0.0015 per 1% increase in silica at the expense of soda. (4) A thermochemical relation of the softening points and the chemical compositions (calculated) closely paralleling the "liquidus" surfaces of Feild and Roysters' system: $CaO{\cdot}Na_2O{\cdot}SiO_2$.

Effects of additions of CaO and MgO upon some physical properties of a glass.* C. W. PARMELEE AND D. T. H. SHAW. The glass consisted of the composition SiO_2, 58%, PbO, 22%, and Na_2O, 20%. CaO and MgO were introduced in small increments separately and together to replace equivalent parts of Na_2O. The following data were obtained: thermal expansions; solubilities; softening points; compressive strengths; moduli of elasticity; indices of refraction. The conduct of these glasses when used as vitreous enamels on metals is discussed.

Effects of additions of zinc oxide and cadmium oxide on simple glasses.* C. W. PARMELEE AND R. G. EHMAN. The glass consisted of the composition SiO_2 58%, PbO 22%, Na_2O 20%. Zinc oxide was introduced in increments of 5% up to a maximum

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of 20% as a substitute for equivalent parts of Na_2O. Similar substitutions were made with CdO. The following physical properties of the glasses were studied; thermal expansions; solubilities in dilute acid; indices of refraction; annealing conduct; analyses of the glasses. The conduct of these glasses as vitreous enamels on metal is discussed.

Results obtained through use of borax in manufacture of tank glasses.* D. D. SCHURTZ. In the manufacture of various types of tank glasses, the introduction of a moderate amount of borax is becoming the general practice. Increased furnace production, less tendency to devitrify, less checking in fabrication, better finish, and more durable ware are indicative of its use. The introduction of borax and some of the problems connected with it are discussed.

Electrochemical behavior of glass.* JOHN BRIGHT FERGUSON. A résumé and discussion of the work of Rebbeck and Mulligan at the University of Toronto,† which dealt with the following phenomena noted during the electrolysis of various glass samples under a variety of conditions: gas evolution and disappearance, anode and cathode gas, solid electrolytic deposits formed in the glass near the one surface and associated electrical effects.

Progress report on Bureau of Standards' investigation of effect of dissolved gases in glass.* R. C. DARNELL. A report of determinations of the dissolved gas content of a soda-lime-silica glass specially prepared from carbonates so as to contain only CO_2 as a dissolved gas. A quantity of gas is found which, under standard conditions, is roughly equal in volume to that of the glass. A method for preparing a glass containing only water vapor as a dissolved gas is outlined.

Modified method for decomposing aluminous silicates for chemical analysis.* A. N. FINN AND J. F. KLEKOTKA. Evidence has been obtained that certain silicates of alumina and allied compounds, especially ceramic materials, can be decomposed for chemical analysis with relatively small amounts of sodium carbonate. Heating an 0.5-gram sample with 0.6-gram sodium carbonate at 875°C for two hours has been found to give satisfactory decomposition.

Dimensional changes caused in a Pyrex glass by heat treatment.* A. Q. TOOL, E. L. PEFFER, AND J. B. SAUNDERS. In previous investigations‡ some apparently exceptional results were obtained by subjecting some glasses containing a relatively high percentage of silica to certain heat treatments. These results concerned variations observed in the amount of heat absorbed as the glasses were being heated, and also changes caused in the densities of the glasses by annealing. Further investigation has yielded additional data which are in accord with the previous results. They indicate that lower densities are obtained by annealing certain of these glasses at temperatures between 500°F and 600°F than at temperatures immediately above or below this range, and also that in certain cases the expansivities of such glasses are reduced somewhat by annealing.

Crystallization relations in soda-lime-silica glasses.* G. W. MOREY. The paper

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†J. W. Rebbeck and J. B. Ferguson, "Evolution of Gas and Its Relation to Sorption and Conductivity" Part I, *Jour. Amer. Chem. Soc.*, **46**, 1991 (1924).

J. W. Rebbeck, M. J. Mulligan, and J. B. Ferguson, "Electrolysis of Soda-Lime Glass," Part II, *Jour. Amer. Ceram. Soc.*, **8** [6], 329–38 (1925).

‡A. Q. Tool and C. G. Eichlin, "Variations in Glass Caused by Heat Treatment," *Jour. Amer. Ceram. Soc.*, **8**, 1 (1925).

A. Q. Tool and E. E. Hill, "The Constitution and Density of Glass," *Jour. Soc. Glass. Tech.*, **9**, 185 (1925).

outlines more exactly the crystallization relations in soda-lime-silica glasses in the neighborhood of the field of glass compositions. This work defines the boundaries of the $Na_2O \cdot 3CaO \cdot 6SiO_2$ field with a precision of one-half of 1% and enables melting points to be estimated within 2°.

Notes on chemical analysis of glass.* G. E. F. LUNDELL. The stability of powdered glass samples, the determination of boron, the determination of fluorine, the determination of silicon in the presence of fluorine, and some further observations on the use of 8-hydroxyquinoline in chemical analysis are presented.

Actions of dust from batch on checker brick of glass furnace regenerators.* D. S. BELIANKIN AND M. A. BESBORODOV. The crusts and glazed slag formations due to the glass batch dust that is carried by the gas current beyond the pots into the regenerators, flues, and burners were examined microscopically by X-rays and chemical analysis. Crystals of nepheline, carnegieite, and mullite are noted. This paper deals with the crusts and glazed surfaces in the regenerating chambers of two different pot furnaces of Drushnaya Gorka glass works.

Expansion-measurements of several glasses by means of self-registering apparatus.* WILLI M. COHN. Applying an apparatus which registers photographically and using quartz glass as control material, the expansion behavior of several glasses upon heating to temperatures above the softening point were investigated. It was shown that with the help of the arrangement discovered, even slight variations in the expansion-temperature curve could be detected which easily escape visual observation. In particular it is possible by utilizing the results of these measurements to regulate the annealing process of the glasses in the most useful manner.

Temperature at which gold-containing glass becomes red and "strain" birefraction disappears. G. TAMMANN AND H. SCHRADER. *Z. anorg. allgem. Chem.*, **184** [1], 293–94 (1929).—Glass containing 3% gold became red upon heating for 6 hours at 392°C. On heating at 388°C for the same period the glass was only rose colored but not deep red. Therefore at 390°C the motion of the gold atoms in the glass is so great that they can combine to form ultramicroscopic particles. A glass quenched in oil at 388°C showed a weak birefraction; when quenched from 383°C it showed no birefraction. On reheating a birefracting glass, the birefraction disappeared but the temperature at which it did so depended on the quenching temperature. The temperature of 390°C at which a gold-containing glass becomes red agrees very well with the temperature of 385°, at which glass shows birefraction on quenching. Both processes require a definite motion of the glass molecules. L.T.B.

Devitrification of glasses. K. TABATA, K. YEGAMI, AND K. TODA. *Researches Electrotech. Lab.* [Japan], **269** [5], 23 pp. (1929).—The effect of the addition of alumina to various glasses upon the phenomena of the surface devitrification has been observed, in the same way as described in the previous reports. The compositions of the glasses used are given.

1.0 R_2O, y SiO_2	1.0 R_2O, 1.5 MgO, y SiO_2
1.0 R_2O, 1.0 PbO, y SiO_2	1.0 R_2O, 1.0 ZnO, y SiO_2
1.0 R_2O, 0.5 BaO, y SiO_2	1.0 R_2O, 1.5 ZnO, y SiO_2
1.0 R_2O, 1.0 MgO, y SiO_2	1.0 R_2O, 2.0 ZnO, y SiO_2
	1.0 R_2O, 0.8 CaO, y SiO_2

The values of y correspond to those glasses of degrees of devitrification 0 to 4 (refer to the previous reports). The quantities of alumina added were 5, 10, and 15% by weight. The results of the experiment are summarized as follows: (1) the more alumina added the higher became the softening temperature; (2) the more alumina

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added, the more devitrification occurred; (3) addition of alumina made, in general, the rate of spontaneous crystallization of silicate greater; (4) addition of alumina to glasses containing K_2O in a larger per cent made the crystallization of SiO_2 greater.

Brittleness of glass as a function of composition. OSKAR KNAPP. *Glashütte*, **59** [9], 146–47 (1929).—The breakability of glass is to a limited extent dependent on certain oxides of the glass. Winkelmann and Schott were the first to study the relation of brittleness to sudden temperature changes. From theoretical considerations they found the following relation:

$$\text{Thermal resistance} = \frac{\text{tension}}{\text{expansibility} \times \text{elasticity}} \times \sqrt{\frac{\text{thermal conductivity}}{\text{density} \times \text{specific heat}}}$$

This formula was tested experimentally by heating glass cubes and beakers to 215°C and quenching in oil. For resistance to breakage due to impact the following formula was derived from experiments in which beakers were allowed to fall on flat plates from varying heights:

$$\text{Impact} = \frac{\text{tension}}{\text{expansibility} \times \text{elasticity}}.$$

L.T.B.

Decolorization of commercial glasses. ANON. *Glashütte*, **59** [19], 332–35 (1929).—Color in glass is often due to ferrous oxide which is present. Decolorization may be accomplished by two methods: (1) chemical and (2) physical. Chemically it may be removed by lowering the melting relations or by adding oxidizing agents such as KNO_3. As_2O_3 is sometimes used and is more efficient. Physical decolorization is usually more complete than decolorization by chemical means. Color is due to the greater absorption of certain wave-lengths of light over that of other wave-lengths. Decolorization, therefore, can be attained by adding to the glass definite amounts of materials which will absorb those colors previously transmitted freely, so that the final absorption of all wave-lengths will be equal. Thus if a glass has a blue-green color, to decolorize it a material must be added which will give it a red color. Such substances are nickel and manganese oxides and selenium. Alkali-rich glasses are more likely to be colored than alkali-poor glasses. L.T.B.

Cullet in glassmaking. ANON. *Nat. Glass Budget*, **45** [34], 3 (1930); *Pottery Gaz.*, **55** [631], 93–97 (1930).—A report is given of "The Function of Cullet in Glassmaking," by W. E. S. Turner, delivered at Leeds, Nov., 1929. In previous papers (see *Ceram. Abs.*, **8** [9], 641 (1929) abstract by Hodkin, Howes, and Turner), proportions of batch and cullet in soda-lime-silica and in potash-lead oxide-silica glasses were described. The present investigations were on the effect of repeated remeltings on the composition and working properties of the same glass originally made from batch. The first series were on simple lime-soda-silica glass, made and remelted many times in a sillimanite pot. The glass made from batch was worked from the pot, broken up, returned to the pot, remelted, worked out again, and samples taken. The amount of corrosion on the pot after the remeltings of cullet was astonishing, and was confirmed by the irregular, yet considerable percentage of ferric oxide and alumina found in the glasses on chemical analysis. The compositions of the glasses were given in full and revealed a diminution in soda as the remeltings progressed, but it was not obvious, from simple inspection, whether this diminution in the alkali was due to actual loss or to change in the proportions of the constituents due to the absorption of material from the pot. The glassworker reported a shortening of the working range, and an increase in brittleness of the glasses with each remelting. The glasses also became darker in color. The absorption of a considerable quantity of pot material by the glasses vitiated all attempt

to determine the effect of remelting alone on the physical properties of the glasses. A further investigation was therefore undertaken, glasses being made and remelted repeatedly in platinum to eliminate the corrosion of the vessel. It was found that the chemical compositions varied but slightly throughout the whole number of samples. There was a slight tendency to diminution of soda as the remelting proceeded, but the differences found were not appreciably greater than analytical error. Little variation was found in the annealing temperatures, the density, or the thermal expansions of the glasses. E.P.R.

Manufacture and properties of glass and their application in illuminating engineering. I. S. ENGLISH. *Glass*, **6** [8], 334–41 (1929).—In attempting the study of the failure of glass by fracture, two distinct cases present themselves: (1) the glass may break spontaneously, or (2) it may be broken by external means. Spontaneous breakage is caused by the presence of an excessive internal stress within the glass itself. In cooling, if one portion of a piece passes through the setting zone before an adjacent portion, *e.g.*, the interior reaches it, then the outside has become rigid while the interior still has to pass through this zone of increased contraction. When such a glass reaches ordinary temperature the center portions are in a state of tension, while the inner zones are in a state of compression. Such a stress distribution can be viewed by means of a strain viewer. The fracture of this glass may occur immediately after, during the cooling of the glass, or it may be delayed for days, months, or even years. As for the breaking of glass by external influences, as far as the illuminating engineer is concerned the most important factor is the capability of glass to withstand high temperatures. Besides this, a certain mechanical strength is required to withstand accidental blows. The three important properties involved in the thermal endurance are expansion, elasticity, and tensile strength. Winkelmann and Schott showed that the value of these properties can be approximately calculated for a glass on the assumption that each 1% of each constituent oxide has a specific effect which can be denoted by a number. Boric oxide, silica, lime, and perhaps alumina and zinc oxide are likely to be most useful in increasing the thermal endurance, and soda the most harmful. With this for a basis new glass compositions were made and tested. The best composition contained 73.3% silica and 16.2% soda. **II.** *Ibid.*, **6** [9], 376–78 (1929).—A heat-resisting glass is much in demand especially in the manufacture of lamps. In some instances, a glass in a flood lamp will be heated to a temperature above 200°C and be subjected suddenly to a shower of water to imitate rain. A glass of this nature melts and works very differently from the ordinary glass. It requires a much higher temperature to bring it to a bubble-free condition; it must be worked at a high temperature and rather quickly, since it has a fairly rapid rate of setting. "Pyrex" meets these conditions very well and has approximately the following composition: 80% SiO_2, 12% B_2O_3, 5% Na_2O, and 2% Al_2O_3. Its coefficient of expansion is about 0.0000033 per °C. At the present time fused silica is the only glass that is any more heat resistant. Another consideration is the durability of glasses with respect to the corroding action of atmospheric agents, the controlling factor being its composition. Soda reduces the durability the most of all the constituents of a glass. Such oxides as alumina, boric oxide, lime, zinc, and silica are the most effective constituents for increasing the durability of a glass. A test for the durability of glass is described which consists briefly of treating grains of glass of a specified size to the action of boiling water for one hour. The grains are placed in a silica Gooch crucible with holes smaller than the grains of glass. The crucible is supported in a vitreosil beaker so that the glass grains are just submerged. Circulation through the grains is caused by a quartz tube hung over the edge of the crucible as a percolator. O.E.M.

New method for fining glass. A. TORGGLER. *Glashütte*, **59** [39], 704–705 (1929).—

Method used to get rid of bubbles in molten glass is to blow into the glass an inert gas such as nitrogen under pressure to increase their size. L.T.B.

Glass frosting plant. ANON. *Nat. Glass Budget*, **45** [35], 7 (1929).—Rowland D. Smith, Corning, N. Y., has been granted a patent for frosting glass articles, the patent being assigned to Corning Glass Works. It covers improvements in frosting solutions, particularly those used for frosting the inside of electric lamp bulbs for producing light-diffusing surfaces. The solution is of improved efficiency over that heretofore employed and is less expensive in its preparation. E.P.R.

Glass as building material in chemical plants. F. ECKERT. *Diamant*, **51** [11], 201–202 (1929).—The various properties of glass which make it an excellent material for use in chemical plants are enumerated and discussed. E.J.V.

Opaque glass as building material. ANON. *Diamant*, **51** [9], 168–69 (1929).—Not only is the great adaptability of this material indicated by an enumeration of the various places in which it can be used but the method of producing it is thoroughly, though briefly, described. E.J.V.

Devitrification phenomena. V. GROSSMAN. *Glastech. Ber.*, **7** [9], 369–74 (1929); *Diamant*, **51** [15], 282 (1929); see also *Ceram. Abs.*, **8** [10], 714 (1929). E.J.V.

Purifying glass. H. KALSING. *Glastech. Ber.*, **7** [9], 386 (1929); *Diamant*, **51** [14], 268 (1929); see also *Ceram. Abs.*, **8** [10], 715 (1929). E.J.V.

Plate glass manufacture by continuous process. C. W. AVERY. *Trans. Amer. Soc. Mech. Eng.*, **51** [19], 57–60 (1929).—Trouble encountered in the development of the continuous process of plate glass manufacture is discussed in this paper. The materials used had to be perfected and an absolutely uniform gas pressure maintained. There were many problems in rolling, annealing, grinding, and polishing that were quite different from previous practice. Cooling of the rolls, and securing a material for them that would withstand the high temperature required considerable study. Much experimenting with the shape, weight, and speed of the various grinding wheels was necessary and after several years of intensive study, a good quality of plate glass has been produced at about one-half the cost of production by old methods. E.P.R.

Plate glass. ANON. *Glass*, **6** [10], 435 (1929).—The use of a furnace for making glass of a high grade presents certain difficulties. When tanks are new high-quality glass may be produced but the quality becomes less satisfactory as the tank blocks wear away. This method combines the use of a pot furnace for high quality glass and the advantages of the continuous rolling process in producing a sheet of uniform thickness. A large hollow roller is continuously rolling on a pair of shafts which support it from the inside. Above this is another roller which is spaced the thickness of glass desired. The glass is teemed from the pot furnace between the large and small rollers at a high velocity producing sheets 60 or 70 ft. long. This sheet is fed into the hot end of a leer on a series of rollers with a peripheral speed equal to that of the big roller. When the glass is set the speed is reduced so that it is properly annealed and ready for grinding and polishing. O.E.M.

Manufacture of glass caskets. ANON. *Ceram. Ind.*, **14** [1], 48–49 (1930).—The DeCamp Consolidated Glass Casket Co. is making the largest pieces of pressed glass ever produced commercially as all of the caskets are made in two solid pieces; a lid and a base of glass five-eighths to three-quarter inches thick. Most of the adult caskets measure 6 ft. in length. These caskets can be pressed at the rate of one every 8 min. F.P.H.

November production of polished plate glass. P. A. HUGHES. *Glass Ind.*, **11** [1], 22 (1930).—The production of polished plate glass for the month of November, 1929, was 12,130,845 sq. ft., as compared with 14,620,904 sq. ft. produced in the preceding

month, October, 1929, and 11,646,064 sq. ft. produced in the corresponding month last year, November, 1928. E.J.V.

Duo-lite laminated glass. ANON. *Nat. Glass Budget*, **45** [35], 8 (1929); *Amer. Glass Rev.*, **49** [13], 25 (1930); *Glass Ind.*, **11** [1], 22 (1930).—A laminated window glass, Duo-lite, is manufactured by the new "Creighton process" of Pittsburgh Sheet Glass (flat drawn) and Dupont's finest Pyralin. It reduces to a minimum the objections of ordinary laminated window glass and yet costs much less than laminated plate glass. Perfect flatness together with absence of waves, makes possible a quality of product not heretofore possible. This process of laminating insures a sandwich which will not separate under the most severe conditions. E.P.R.

Compound glass. W. O. *Diamant*, **51** [13], 242–43 (1929).—A brief summary of some of the European patents for the production of compound or laminated glass is given. The different cementing media used are discussed. E.J.V.

Effective safety system for glass plant. C. E. RALSTON. *Glass Ind.*, **11** [1], 4–7 (1930).—The methods pursued by the Pittsburgh Plate Glass Co. to safeguard their employees by development of special protecting media such as leather cuffs, leather spats, leather half-gloves, aprons, knee pads, etc., are briefly discussed. E.J.V.

Resistant hollow ware. HUGO KÜHL. *Glashütte*, **59** [13], 217–19 (1929).—Resistant glassware has the following general characteristics: (1) proper composition, (2) homogeneity, and (3) proper annealing. K. cites some compositions and shows how they may be improved in order to make a more resistant glassware. A discussion on mixing glass raw materials and a method to cool glass in order to obtain good ware is given. L.T.B.

Reënforced glass. ANON. Dept. Sci. Ind. Research [London], *Rept. Bldg. Research Board*, No. 101 (1923).—Wired glass of the type used for roof glazing and similar purposes is liable to crack. Investigations have indicated that the wire reënforcement sets up internal stresses. Comparative tests of a newly-developed type consisting of a square mesh of steel wire spot welded at the intersections, and the ordinary type of steel wire with hexagonal mesh twisted together, the former gave much less internal strain and was rather stronger in mechanical tests. W.L.

Properties and applications of vita glass. F. E. LAMPLOUGH. *Glass*, **6** [8], 342–46 (1929); for abstract see *Ceram. Abs.*, **8** [9], 640 (1929). O.E.M.

Manufacture of fused quartz windows. ANON. *Glass*, **6** [10], 428 (1929).—The fact that ordinary window glass cuts out ultra-violet rays from sunlight created a demand for a glass transmitting the health-giving rays to be used in solariums. Fused quartz was known as the best medium for the purpose. The present process is to fuse quartz crystal, crushed to $^1/_4$-inch mesh, in a vacuum on flat graphite disks between thin graphite slabs in the form of a square $7^1/_2$ by $7^1/_2$ in. A number of these trays are stacked in a form and placed in a high-temperature furnace. When the quartz is fused, nitrogen gas is admitted to the furnace at a pressure of 150 lbs. per sq. in. This method does away with cutting, grinding, and polishing. O.E.M.

Effect of ultra-violet radiation on window glass. ANON. *Glass Ind.*, **11** [1], 7–8 (1930).—A brief résumé of the results obtained by Coblentz and Stair (see *Ceram. Abs.*, **8** [5], 332 (1929), and **9** [1], 22 (1930)), and Wood and Leathwood (see *Ceram. Abs.*, **9** [2], 91 (1930)) of the Research Laboratory of the Crown Glass Works at St. Helen's, England, in their tests of ultra-violet ray transmitting glass is given. E.J.V.

Sunlight in schoolrooms. ANON. *Nat. Glass Budget*, **45** [35], 16 (1929).—Birmingham, England, and Birmingham, Mich., have introduced ultra-violet light in schoolrooms and have succeeded in increasing scholastic efficiency. E.P.R.

Many-sidedness of glass. E. C. SULLIVAN. *Ind. Eng. Chem.*, **21** [2], 177–80 (1929); for abstract see *Ceram. Abs.*, **8** [6], 403 (1929). R.G.M.

Storm-glazing glass. ANON. *Amer. Glass Rev.*, **49** [11], 34 (1930).—An outstanding glazing installation has been done by the Swinton Art Glass Works on a cathedral in Toledo to afford protection for large stained glass memorial windows. This special glass is one-fourth inch thick, of extraordinary strength and wind resistance, and is made up of more than 3000 separate pieces of glass. A special cement that never hardens is used, which takes on the same properties as live rubber, providing adequately for the expansion and contraction of both glass and metal with seasonal weather changes. A copper clip is made so that the glass is held securely in place in the grooved stone casements. E.P.R.

Glass in factory buildings. H. S. JACOBY. *Amer. Glass Rev.*, **49** [13], 26–29 (1930).—Three-fourths of the sidewall area of the modern industrial building is of glass. The roof, too, often carries large expanses of sash. Studies into the problem of daylight have discovered that a minimum intensity of a 10-ft. candle provides sufficient light for most manufacturing operations. Several obscure or figured surfaces have come into wide use and figured surfaces are available in a number of different designs. All serve effectively to screen the vision. Some types of glass diffuse the direct rays of the sun so that the intensity of light is reduced at points near the windows and is increased at more distant points. This glass helps to "level" the light and to reduce shadows. Factory ribbed is the best known type of obscuring glass. Its surface consists of many small parallel ribs of prismatic form and is usually installed with the ribs vertical, thus neutralizing the shadows cast by columns, mullions, pilasters, and other vertical obstructions. If the ribs are horizontal they will help to transmit the light back into the center of the building. When the sun shines upon this glass it is intensely luminous. A somewhat similar type of glass is figured with a heavy V-shaped scoring that forms parallel ribs of distinct prismatic form. This glass functions like ribbed glass but because the figure is larger, the individual prism surfaces stand out in alternate contrasting bands of light and dark. In skylights, this glass diffuses the sunlight evenly over the floor area. Another type of glass that has some into wide use has a surface formed by two sets of shallow parallel scores at right angles to each other. The resulting figure consists of many small, regularly spaced projections of somewhat pyramidal form. This glass diffuses the light in both the vertical and horizontal planes and the illumination is thoroughly diffused. Hammered glass, so-called, is a rough glass with figures that resemble hammer marks, comparatively smooth, and easy to clean. It diffuses the light sufficiently for most requirements and does not have the intensely luminous appearance that is characteristic of many figured surfaces. It is especially desirable for use in sidewall sash because workmen who face it are not subjected to serious glare. Glass in various shades of amber has been advanced by the glass industry as a means of alleviating heat during the summer months, and reducing the glare from direct sunlight. It filters the heat rays from the sunlight. As a result of a series of tests with many types of glass, a large chemical concern chose amber glass for one of its buildings that is to house tanks of highly explosive gas. These tests showed that amber glass absorbs the heat rays and prevents explosions. E.P.R.

Glass joints. ANON. *Commercial Standards Monthly*, **6** [6], 182 (1929).—The users of laboratory glassware will welcome the efforts of manufacturers to adopt a standard taper and a set of standard diameters for interchangeable ground-glass joints. The use of such joints will greatly facilitate the setting-up of complicated pieces of laboratory apparatus and will result in enormous savings in the event of breakage, since it will be possible to substitute the part broken without discarding the entire piece of apparatus. A proposed standard was agreed upon by manufacturers with the coöperation of the Bureau of Standards at a meeting held in October. E.J.V.

Glass containers simplified. W. E. BRAITHWAITE. *Commercial Standards Monthly*,

6 [6], 162–63 (1929); *Nat. Glass Budget*, **45** [37], 12 (1930).—Through the coöperation of manufacturers and the Department of Commerce simplified practice recommendations have been developed which reduced the variety of milk bottles from 49 to 4, of preserve jars from 36 to 8, jelly glasses from 24 to 7, and apple-butter jars from 6 to 4. Programs for other glass container simplifications were outlined. E.J.V.

Precision devices for glass manufacture. ANON. *Glass Ind.*, **11** [1], 20 (1930).—Toledo Precision Devices, Inc., a recently organized subsidiary of the Toledo Scale Co., are producing more than 50 different precision instruments and devices, a number of which apply directly to glass manufacture. Their use varies from the gaging of glass tubing to the determination of final glass area by means of precision weighing. Besides the distribution of these products, an investigation department is maintained where specific problems of glass manufacture are worked out upon submission. E.J.V.

Batch mixer. ANON. *Glass*, **6** [8], 331–32 (1929).—The Eirich counter-current mixer consists of a circular pan rotating about a verticle axis. Fitted inside the pan are mixing stars which rotate in opposite direction to the pan itself. These stars may consist either of 2 mixing blades and a steel roller or of 3 blades. In addition to the mixing arms there are side and bottom edge scrapers which force every particle of the batch into the zone of the mixing stars. O.E.M.

New research microscope. ANON. *Glass Ind.*, **11** [1], 20 (1930).—Capable of magnifying an object to 2250 times its natural size and of shifting its magnification from first to fourth power or vice versa, what is believed to be the world's most powerful research microscope has just been completed at the Bausch & Lomb Optical Co., Rochester, N. Y. E.J.V.

Continuous tank fitted with combination oil- and gas-firing system. ANON. *Ceram. Ind.*, **14** [1], 50–55 (1930).—Experiments with both oil and gas separately at the Inland Glass Co., revealed disadvantages in each fuel. Oil alone was found to be too dirty and gas alone did not give the radiation necessary for quick melting. By combining the two fuels and using both simultaneously through the same burner the objections were overcome and some real advantages obtained. The system provides a desirable ease of control and makes possible the control of temperature in different parts of the tanks. The installation consists of a specially designed mixing fan and burner. Two burners are used on the continuous tank and one burner on the day tanks. The gas is mixed with the proper amount of air at the fan and forced to the nozzle by a pressure equal approximately to 6 in. of water. The oil, 24°Bé, is heated to 180°F and piped to the burners where it is mixed. It is atomized or vaporized by the heat of the gas flame which gives efficient combustion. F.P.H.

Sale of Firthite. ANON. *Nat. Glass Budget*, **45** [36], 3 (1930); *Amer. Glass Rev.*, **49** [19], 19 (1930).—H. L. Dixon Co., Pittsburgh, has contracted for the exclusive sale in the glass industry of Firthite, a new metal of diamond-like hardness. Firthite offers a new method for cutting molds, increasing their efficiency and reducing costs. It can be used in cleaning molds as well as in making them. E.P.R.

Glass furnace construction. A. ALISON. *Glass*, **6** [4], 136 (1929).—A summary of the frictional losses during evacuation is tabulated, from which it will be observed that the friction on the gas side is slightly in excess of that on the air side, and that the three-burner design introduces greater losses than those obtained by the two-burner arrangement. The chimney for withdrawing gases is considered. The stack must overcome (1) the negative draft, (2) the frictional losses, and (3) impress a velocity upon the gases. With the regenerators at the same mean temperature and of the same height the negative draft will be the same on both gas and air sections. Consideration of the size of the flues and ports and the velocity of the gases at various temperatures are

taken into account. Calculations involving the volume of the gases passing through the various ports at given temperatures are shown in determining the number of burners to be used. It is usually considered advisable that the products of combustion should dwell in the combustion chamber for about three seconds in order to transfer their heat satisfactorily to the glass. This being the case, the volume of the combustion chamber bears a definite relationship to the volume of the gases entering it. *Ibid.*, **6** [8], 328–29 (1929).—A. presents a chart to simplify the calculation for exit velocities. A sample calculation is given. The height of the chimney must be such that the draft created will be sufficient to overcome (1) the static draft in the regenerators, (2) impart the requisite velocity to the outgoing gases, and (3) overcome the frictional losses. The equation given is negative draft plus velocity head plus friction in flues equals draft induced by stack minus friction in stack. A discussion of flues, air valves, and gas valves is given. An approximate heat balance for a furnace of 1 T. hr. capacity is given. About 9.2% of the heat supplied is used in melting the glass, 4.5 in preheating the air in the flues, 30.0 in preheating air in generator, 14.5 in preheating gas, 14.5 in waste products at 555°F, and 27.3 lost by radiation, conduction, etc. Insulation is advantageous in all cases where its use does not maintain the interior hot face of the brickwork at a temperature near or above its fusion point. *Ibid.*, **6** [9], 372–75 (1929).—Loss of heat from an exposed wall is discussed with relation to data and equations necessary for its determination. The conductivity coefficient, K, of the tile in the wall is expressed in B.t.u.'s per sq. ft. per hr. through a section 1 in. thick for a temperature difference between the hot and cold faces of 1°F. Values of K given are (1) for fire brick $K = 0.0028T$ 5.4, (2) for silica brick $K = 0.0032T$ 6.5, (3) for red brick $K = 0.0022T$ 5.25, (4) for insulating brick $K = 0.0002T$ 0.75, where T is in °F. To obtain the heat loss through the tile, K is multiplied by the difference in temperature between the hot and cold faces, and is divided by the thickness of the tile. A chart is given showing the heat losses through fire brick of various thicknesses at various temperatures. *Ibid.*, **6** [10], 420–23(1929).—Calculations are given to show the comparison of a furnace wall having no insulation to one that does have insulation; *i.e.*, a furnace wall composed of 9 in. of fire brick backed by 9 in. of red brick may show an outside temperature of 300°F and an inside temperature of 1710°F, while a wall composed of 9 in. of fire brick, 3 in. of insulation, and 9 in. of red brick having the same heat loss will show an inside temperature substantially higher than 1710°F. The same wall with an inside temperature of 1710°F will have an outside temperature much less than 300°F and a heat loss which is correspondingly less. It is shown that in either case the insulation will cause a conservation of heat. The figures show that a wall composed of 9 in. of fire brick and 9 in. of red brick has a heat loss almost $2^1/_2$ times that for a wall insulated with 3 in. of insulation at an inside temperature of 3160°F. The thickness of the fire brick must be regulated so that the insulation will be protected. Equations for the above calculations and charts and figures are given for the graphical solution. Thus it is possible to obtain the same values of heat transfer by two different methods. *Ibid.*, **6** [11], 460–62 (1929).—This is a continuation of A.'s graphical method of finding the heat transfer through a furnace wall. A combined chart is given for fire brick, red brick, and insulating brick. This chart includes B.t.u.'s/sq. ft./hr. of the inside temperature, the outside temperature, and thickness in inches of red, insulation, and fire brick. It is stated that overlaying the crown with insulating and semi-insulating materials can only be safely done if, after so doing, the inside temperature of the arch brick remains lower than the fusing point, which is about 3000°F. In case of the crown, where overheating is likely to be encountered, the position of the thrust line may be so altered by the failure of the inside of the brick as to impair the stability of the arch. A chart of thermal conductivity in B.t.u.'s/sq. ft./hr./°F/in.

is given for silica, red, fire, and insulation brick. A. states that the graphical method requires much less time, is sufficiently accurate, and offers less likelihood of mistakes than the mathematical method in furnace design. *Ibid.*, **6** [12], 508–10 (1929).—The examples of arithmetical solutions as given from time to time are cases that tend to show the solution conspicuously more tedious to obtain than a graphical one. The appendix is given in this number of the notes and includes particulars of seven tank furnaces taken from practice but not necessarily embodying the best design. Data for the following are given: melting tank, burners, regenerators, flues, and capacity. Tables are given for chimney draft, points for plotting heat-loss curve from equation, points for plotting specific heat and heat-content curves of hydrogen, nitrogen, methane, air, carbon dioxide, and water vapor. For previous abstract see *Ceram. Abs.*, **8** [6], 402 (1929). O.E.M.

Oklahoma window-glass plant. ANON. *Glass Ind.*, **11** [1], 20 (1930).—The two million dollar window-glass manufacturing plant under construction at Henryetta, Okla., by the Pittsburgh Plate Glass Co. will be in operation by March 15, 1930. In the clay building, the only structure completed up to this time, refractory products are being made and seasoned so as to be ready when production starts. E.J.V.

Addition to Corning plant. ANON. *Glass Ind.*, **11** [1], 21 (1930).—The Corning Glass Works, Corning, N. Y., is constructing a new glass tube manufacturing plant which will include a steel tank building, a steel and brick building to house drawing equipment, and a boiler house. E.J.V.

Glass production in France. CHARLES HOUTART. *Pottery Gaz.*, **55** [631], 91 (1930).—H., having traced the history of glass production leading up to the French glassmaking industry, says that with a combination of science, technique, and business acumen the French glass industry has achieved an improved production accompanied by a great reduction in cost. Bottle making has made great advances in quantity, while the same may be said of window glass. Besides the danger of over-production there is the constant possibility of the installation of mechanical plants in various countries that previously bought glass goods in France. France can produce twice her consumption in window glass, 22,000,000 sq. m. of sheet glass for a consumption of barely 10,000,000 sq. m. Many factories still produce bottles by hand. H. urges the adoption of the Lynch machine generally. E.J.V.

Czechoslovakian glass industry. ANON. *Pottery Gaz.*, **55** [631], 129 (1930).—The situation in the glass industry is satisfactory. Czechoslovakia is now the 3rd largest exporter of glass in the world, this commodity forming 19% of the total exports of the country; the increase in exports this year being greater than the increase in exports from Belgium. The total value of exports of glass since the foundation of the State has now reached 15 milliard crowns, while imports amount to only half a milliard crown. E.J.V.

Glass production in Europe. ANON. *Pottery Gaz.*, **55** [631], 129 (1930).—There are at present in the European flat glass industry 410 Fourcault and 31 Libbey-Owens machines at work, having a total production capacity of about 160 million meters a year. Germany has 50 Fourcault and 6 Libbey-Owens machines, with a producing capacity of about 22.2 million sq. m. Data of a similar type for other countries in Europe are also presented in a table. E.J.V.

Glass industries of Eastern Europe. J. E. BARABAS. *Glass Ind.*, **11** [1], 19 (1930).—There is one glass plant in Gebedje, Bulgaria, equipped with one continuous tank and one pot furnace for bottles made by semi-automatic devices. A new window-glass factory will be erected near Sofia. There are two glass plants in Greece. The Verrerie "Hermes" is the oldest glass factory of Greece, founded in 1870, and is situated in Piraeus, the seaport of Athens. The production consists of bottles, jars, domestic

and pressed glassware, but the quantity put on the market is small. They have two pot furnaces but no continuous tank. The second plant, founded in 1912, is the property of the Société Hellénique Anonyme de Produits et de Engrai Chimiques, Athens. This plant is favorably situated in Piraeus and is a very well-equipped, modern plant which has been reorganized and enlarged recently. Bottles, jars, domestic, press and illuminating blown glassware will be equally produced but of greater importance is the fact that the manufacture of window glass is being taken up. The plant employs about 700 workmen and is running 3 continuous tanks and one pot furnace. Flat glass will be made by one Fourcault machine, while the bottles will partly be made by 8 "Roirant" suction full-automatic machines. This machinery proves the tendency toward rationalization. Turkey has no glass industry at all. There have been two small plants in Constantinople but they have not been worked for many years. While until the peace treaty, Servia had but one glass plant, at Paracin, the newly attached Slovenia possessed several plants. One named Hrastnik is the most important. The Slovenian glass works are all controlled by the United Glass Plants Co., Ltd. By buying the Paracin plant, they obtained control of the entire industry of Jugoslavia. The plants are manufacturing all kinds of bottles, tableware, pressed ware, and lighting articles in every color and fairly good quality. The factories are well-equipped and there is a sound tendency for the gradual application of modern devices. The Hrastnik plant lately bought several "Roirant" full-automatic bottle-making machines. The production, about 20,000 T per year, does not cover the whole inland demand, so that until lately considerable quantities have been imported into Jugoslavia. E.J.V.

Russians claim world's largest glassworks. ANON. *Pottery Gaz.*, **55** [631], 129 (1930).—The construction of the "largest glassworks in the world" will be begun in Lisitchansk in 1930. The annual output of this factory will be 22,000,000 sq. m. of common window and crown glass. The plant will include 8 tanks and 18 Fourcault machines. The total cost of the factory will be 35,000,000 roubles. E.J.V.

PATENTS

Melting or fusing glass, quartz, or ceramic materials into metal caps, etc. KARL DONAT. U. S. 1,740,443, Dec. 24, 1929. In the method of fusing metal parts together with glass, quartz, or ceramic materials plastic at high temperatures, the heating of the fusing point by means of a gas current heated to the desired fusing temperature before it reaches the fusing point.

Making composite glass. WILLIAM O. LYTLE. U. S. 1,740,989, Dec. 24, 1929. In combination in apparatus for use in securing together a set of sheets of similar size arranged in a pile, comprising a frame fitting around the sheets, and approximating in thickness the thickness of the set, and a relatively flat container of soft rubber composition closed at one end and open at the other in which the frame fits with the end of the frame projecting into the open end of the container and making sealing contact therewith.

Glass-surfacing apparatus. HALBERT K. HITCHCOCK. U. S. 1,741,021, Dec. 24, 1929. The combination with a plurality of surfacing cars or tables mounted for movement along a track and each having a glass-supporting surface, of an exhaust system for each table comprising communications leading down from the surface of the table and connections therefrom extending to each end of the table, coupling devices at each end of each table arranged to couple the ends of the connections at the opposing ends of the cars together in communicating relation when the tables are brought into abutting relation, check valves at the ends of the connections adapted to close when the abutting ends of the tables are separated, an air-exhausting apparatus arranged adjacent the track and means whereby the exhausting apparatus may be connected to the exhaust system of each table in turn.

Handling glass sheets. WALTER G. KOUPAL AND JOSEPH H. REDSHAW. U. S. 1,741,026, Dec. 24, 1929. Apparatus for handling glass sheets comprising a movable supporting means, a laterally extending vacuum frame pivotally supported thereon, a suction cup pivoted to the end of the frame for engaging the face of a vertical glass sheet, and means for holding the cup yieldingly with its face in substantially a vertical plane.

Electric furnace. BERNARD LONG. U. S. 1,741,469, Dec. 31, 1929. In an electric furnace an electrode of molten metal projecting into the furnace and extending to the outside thereof.

Process and slot member for manufacturing glass sheets. NICOLAI PAWLOWITSCH KRASNIKOV. U. S. 1,741,523, Dec. 31, 1929. A slot member for drawing glass sheets, comprising in combination inner walls confining a drawing slot and a lower enlarged entrance space, outer walls and an inner partition wall forming separate hollow spaces along the enlarged entrance space and along the slot, and fittings adapted to pass different temperature-regulating fluids through the separate hollow spaces.

Sealing off a hollow glass body from an annular glass body. PANCRAS SCHOONENBERG. U. S. 1,741,662, Dec. 31, 1929. A process for fusing off a part from an open hollow glass body, consisting in directing a flame in the desired plane of severance against the inner surface of the hollow body until the glass melts after which the glass body and the part are separated, while during the fusing-off operation the glass body and the flame are rotated relatively to each other.

Apparatus for blowing glass. JOHN A. MILLIKEN. U. S. 1,741,708, Dec. 31, 1929. (1) A glass-blowing machine provided with a press mold and a blow mold movable as a unit, a gripping member normally disposed above the press mold, means for directing a slug of glass into the press mold, means for expanding it into engagement with the gripping member, means for removing the press mold, means for moving a blow mold vertically into operative position with respect to the glass slug, and a blow pipe for expanding the slug of glass into the mold. (2) The combination in a glass-blowing machine provided with a carrier, of a blow pipe supported upon the carrier, a blow mold having a relatively movable bottom portion both movable vertically into operative relation to the pipe, the bottom having a depending member, and means disposed adjacent to the carrier to engage the depending member for holding the bottom portion against retractive movement when the mold is withdrawn from the blow pipe. (3) In a glass-blowing apparatus, the combination with a rotatable mold table provided with glass-blowing units, of take-off mechanism comprising a cam member carried by the table, the cam member having a plurality of cam surfaces, one for each blowing unit, an actuator lever mounted on a support normally stationary with respect to the table, means normally holding one end of the lever in engagement with the cam member, and a take-off device connected with and oscillated by the actuator lever. (4) In a glass-blowing apparatus, the combination with a mold carrier, a blow mold supported thereby, a spray device, means for supplying cooling fluid to the spray device, means operated by movement of the mold carrier for causing the mold to temporarily enclose the spray device, and means also operated by movement of the mold carrier for regulating the supply of cooling fluid passing to the spray device.

Sheet-glass manufacture. LAURENCE E. STEWART. U. S. 1,741,886, Dec. 31, 1929. The combination with a glass-melting tank, of a drawing pot in juxtaposition to the tank and having an inner wall defining a passage leading from the tank to a point of draw, an outer wall housing the inner wall and having flues therein, means for supplying heat to the flues, a heat-insulating cover upon the exterior of the outer wall, and a casing binding the parts together.

Manufacture of window glass. MAX BICHEROUX. U. S. 1,741,912, Dec. 31, 1929.

In a device for making window glass from a mass of refined molten glass, in combination at least one pair of adjustable forming rolls adapted to roll the glass mass into a primary sheet of a thickness greater than the thickness of the finished product, means to support the glass sheet during its forward movement, a draft device for seizing the rolled sheet of glass at its forward end and drawing it to the desired final thickness, and revolving rollers arranged transversely of the sheet at such points where the sheet is still plastic, these rollers having oppositely handed helical threads extending from the middle to the ends of the rollers and designed to act on the sheet for smoothing it and stretching it in the direction of its width.

Electric furnace. CORNELIUS ERIC CORNELIUS. U. S. 1,741,977, Dec. 31, 1929. An electric furnace for melting or producing glass, water glass, cement, and other substances, in which the substance which is melted or produced forms a resistance for the electric current, comprising solid metal electrodes having a large heat-accumulating capacity in relation to the substance to be treated, the electrodes being free-standing on the bottom of the furnace and exposed to the liquid resistance.

Charging molten glass into molds. CARL HENRY RANKIN. U. S. 1,742,098, Dec. 31, 1929. Apparatus for delivering a charge of molten glass to a mold, comprising a U-shaped funnel, whereof one part is movable rotationally in the other part.

Glass-grooving machine. HENRY A. SCHEIDEMAN. U. S. 1,742,101, Dec. 31, 1929. A device comprising in combination a support, a frame, means for attaching the frame to the support so that it will move in a rectilinear path, means suspended from the underside of the frame work for supporting a glass plate and means for fastening the glass plate to the supporting means.

Leer feeder. CRAIG L. DOTSON. U. S. 1,742,239, Jan. 7, 1930. A leer feeder including a plurality of guides for delivering glassware to a leer, means for oscillating the guides to arrange the ware in the leer, a rotatable member associated with each of the guides, a conveyer common to the members, and means adapted to feed the ware from the members to the guides.

Glass blowing. C. R. NIXON. Brit. 320,798, Dec. 11, 1929. In an automatic machine for blowing bottles, jars, and like hollow glass articles, a parison is not shaped by a single mold, as usual, but is formed in two molds one of which receives a charge of glass and shapes it into a blank while the other forms the blank into a parison.

Glass manufacture. PILKINGTON BROS., LTD., AND D. V. PHELPS. Brit. 320,004, Dec. 18, 1929. Relates to glass which is transparent to ultra-violet rays, and to the tendency of this glass to lose its power of transmitting the rays. According to the invention, a glass which does not lose materially its transparency to the rays is made by insuring that all, or nearly all, of the iron that may be present in the glass is in the form of ferric oxide. The iron is oxidized to the ferric condition either by melting under oxidizing conditions or, preferably, by introducing into the batch an oxidizing agent, such as potassium nitrate. Specification 263,410 is referred to.

Compound transparent sheets. J. H. ROBERTSON. Brit. 321,157, Dec. 27, 1929. Drawn glass sheets are united to each face of a central sheet of celluloid, etc., by means of a coating of gelatin dissolved in phenol applied cold to the glass and allowed to set, the coated sheets being immersed in a bath of propyl alcohol or industrial spirit and gently pressed on a sheet of celluloid, etc., placed between them. While soft the gelatin solution may have applied thereto a layer of celluloid dissolved in amyl acetate with or without a small quantity of phenol. The gelatin solution is formed by warming 20 parts pure phenol crystals with 1 part of distilled water and adding 4 to 8 parts of hard gelatin, the solution being filtered. When removed from the alcohol bath the sheets are pressed between absorbent materials at 200 lbs. and 50 to 60°C temperature for 10 to 15 minutes. When a center sheet of cellulose acetate is used it is coated

with a 10% alcoholic solution of gelatin or an acetone solution of celluloid. The glass is cleaned by nitric acid or a polishing powder with subsequent washing in running distilled water. A sealing mixture for the edges may consist of 20 parts resin, 20 parts beeswax, and one part of tallow melted and stirred with 10 parts of precipitated chalk.

Compound transparent sheets. C. H. FIELD AND D. HASLETT. Brit. 321,189, Dec. 27, 1929. Two sheets of glass and an intermediate sheet of cellulose derivative are united by adhesive by the simultaneous action of external pressure and of a vacuum to extract air and solvent, etc., from between the sheets. The compound sheet is preferably enclosed within a frame and covered with wire gauze and outer rubber sheets hermetically clamped in a bolted frame. The interior of the frame is in communication with a vacuum tank by connections and is partially exhausted while pressure, by a fluid preferably, is applied externally. The adhesive used consists of equal parts of a solution of Canada balsam in xylene of the consistency of syrup and a solution of glycerine phenol-formaldehyde resin in 40% aqueous alcohol of similar consistency. Specification 310,995 is referred to.

Heavy Clay Products

Simulative service tests for glazed building materials.* J. OTIS EVERHART. Several methods of conducting freezing and thawing tests have been compared with each other and with the standard autoclave test with regard to type and rate of failure. Data indicate that the autoclave test alone is not sufficient to predict behavior of glazed ware in service, especially in the more severe climates. Glazes follow very definite laws as to rate of failure under conditions of freezing and thawing. Curves have been developed which indicate the nature of these laws very clearly. Considerable data have been developed on the effect of freezing on the porosity of brick and on the nature of failure of glazes.

Relation of Brinell hardness to compressive and transverse strength of building brick.* J. W. MCBURNEY. The Brinell hardness of a variety of makes of clay and shale building brick was determined by the method of Le Chatelier. These data indicate a high degree of correlation between Brinell hardness and flat compressive strength.

Improved Goodner mercury volumeter.* J. F. MCMAHON. This paper discusses several mechanical improvements to the Goodner mercury volumeter which include a counterbalance for the burette, an automatic light system, and a plunging device. The greater part of the paper is given to discussing and explaining the construction, operation, and advantages of the plunging device. This device consists essentially of two parts, (1) a plunging rod with fixed moving limits which is operated by hand above the mercury, and (2) a wire basket which is built in such a fashion as to allow the insertion and removal of briquets, being open when out of the mercury reservoir and closed when submerged in the mercury. The advantages of this mechanism are as follows: (1) no string or string marks, (2) cleaner mercury, (3) no bulky weight to be deftly handled, (4) less handling of briquets, and (5) more ease and speed in operation.

Method for determining loss of weight of clays during firing.* W. R. MORGAN. A simple apparatus has been devised for the comparison of the loss of weight of clays during firing by the direct weighing of the sample while suspended in the furnace. Preliminary results indicate that while the total loss of weight of the different clays varies considerably, the losses in any temperature range expressed in per cent of the total

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*Paper presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Toronto, Ont., February, 1930. When this paper is published reference will be given.

weight lost at 1800°F show a much closer relationship. The comparative ease of control will make it possible to examine the clays under a wide range of conditions.

Clay sewerpipe manufacture. Application of method for checking flue-gas analyses to ceramic kilns. Part IX.* E. A. HERTZELL. A method for checking flue-gas analyses is discussed and applied to Orsat data obtained during the firing of sewerpipe kilns. Calculations are made for kilns fired by coal, fuel oil, and natural gas. Discrepancies are noted and possible reasons for them advanced. Conditions under which the check applies are presented.

Clay sewerpipe manufacture. X. Measurement of moisture loss in kilns.* ROBERT L. BLESSING. A brief discussion of methods attempted in the kiln investigation conducted by the Mellon Institute† for the Clay Products Association. The difficulties encountered in using methods which were discarded and the assumption upon which the method used was based. Data and curves are given to indicate the rates of moisture removal based on weight loss during normal water-smoking period and additional loss at higher temperatures. The information obtained gives conditions which show both continuous and non-continuous losses making it difficult to judge the end of water-smoking period by loss of weight methods. The application of data to heat-balance determinations. A concluding discussion covers variation of total moisture in ware and its significance with possible explanation of weight loss at temperatures above water-smoking and danger of using fast rates during this range.

Laboratory test kilns.* A. S. WATTS AND J. L. CARRUTHERS. Three gas-fired downdraft test kilns recently built by the Ceramic Engineering Department, Ohio State University, are described. Detailed drawings and bills of materials for each of the kilns are included in the paper. Operating methods and results obtained for each kiln are discussed.

Fire test equipment of the Engineering Experiment Station of the Ohio State University.* HARRY D. FOSTER. A concise description is given of the Engineering Experiment Station equipment and it is illustrated by results of several typical tests.

Production of salt glaze by use of slip applied to surface of ware.* J. OTIS EVERHART. Glazed surfaces can be produced on the face of ware made from practically any clay or shale having a maturing temperature of cone 1 or more by coating the face of the ware with a slip containing sodium chloride. Various concentrations of salt in the slip have been used. Lower concentrations do not produce glazes but develop interesting surface and color effects. Sodium carbonate has also been used successfully. Metallic oxides may be used to produce variation in color of the glaze. This method shows promise as a means of securing salt glazes in kilns which have heretofore been considered impractical for salt-glazing purposes, although it has been developed only in the laboratory stage at the present time.

New process of producing vitrified ceramic products.* JOSEPH B. SHAW AND MYRIL C. SHAW. This process has been developed to satisfy an urgent need for a cheaper and better road building material. Incidentally, it will supply a need for massive vitrified clay products wherever such materials may be needed to replace concrete structures and it is probable that the product will be more cheaply produced than concrete. The process has been worked out in coöperation with U. S. Senator W. B. Pine, of Oklahoma. The product is primarily intended for structural purposes and will utilize enormous tonnages of clay and shale.

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†Conducted by R. E. Arnold (in charge), R. L. Blessing, E. A. Hertzell, H. C. Harrison, G. R. Pole, and C. E. Parmelee under the supervision of E. Ward Tillotson, Asistant Director, Mellon Institute.

Operating properties in clay mining.* H. E. NOLD. Actual problems, the cause, and possible solution are described. Calculations are given showing the economies of good drainage, well upkept equipment, and sane management of clay mines. Observations show that clay is wasted, mining hazardous and unnecessarily expensive in several of the clay mines examined. Recommendations are made.

Construction and operation of special diamond core drill for exploring shale deposits.* V. W. BOEKER. A brief description of a standard diamond core drill is given and the failure of such a drill to meet fully the requirements of shale prospecting is discussed. The construction and operation of a modified drill especially adapted to shale prospecting are explained and illustrated. Operating data are given and the results obtained are reported.

Handling heavy clay ware with elevating platform storage battery trucks.* H. R. STRAIGHT. The wheeling cost is compared with mechanical transportation, taking into account the upkeep and depreciation of the mechanical and electrical equipment.

Notes on adjustment of dies to prevent cracked ware in drying.* ELLIS LOVEJOY AND H. B. HENDERSON. This paper illustrates faulty and cracked ware in consequence of improperly adjusted dies for stiff-mud products.

Variation in physical properties across extruded column.* W. H. VAUGHAN. A grooved single ribbon die was re-machined to produce six one-inch columns in place of a $^3/_4$- by 6-inch column. Bars were made from the columns. Variations in shrinkage, strength, absorption, and stratification were measured and used to explain some die troubles.

Drier problems with calculations.* JOHN L. CARRUTHERS. This paper describes the application of the Carrier Humidity Chart to control and design problems of waste heat driers in particular and other driers. Methods of overcoming condensation and calculating the amount of heat and volume of air required are discussed with examples shown. A method for making a simple, practical heat balance of a waste-heat drier is also described.

Early brick-making and some old brick buildings in Virginia.* ELLIS LOVEJOY AND H. B. HENDERSON. Views of old brick buildings in Virginia and a brief description of the production of the brick product, particularly glazed brick.

Ceramic resources of Oklahoma and their development.* L. F. SHEERAR. A summary is presented of the economic geology of Oklahoma relative to clays and shales, suitable for clay products and cements and other resources such as glass sands, molding sands, etc. The present status of ceramic manufacture with estimated yearly production is given and a report on the clay survey now being conducted. An outline of the work being done by the state institutions to promote ceramic development is also given.

Unusual scum coating brick.* H. B. HENDERSON. A heavy white fuzzy coating on brick, developed in the firing, consisting entirely of silica is described.

Construction of water-tight brick masonry.* F. O. ANDEREGG. Some 300 panels have been erected to determine the effect of some of the various factors of different brick, mortars, workmanship, and design in causing leaky brick walls. The brick varied in absorption from 0.6 to over 12% of their weight when placed flat side down in $^1/_8$ inch of water for ten minutes. The mortars included both the lean and the richest mixes of lime and Portland cement in varying proportions and a large number of masonry cements. Most of the panels one brick in thickness leaked in half an hour on being sprayed with a hose. Very few mortars were found that were quite tight. Those panels with an air space between the front and the backing allowed

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no water to pass clear through the wall. Many panels have been broken in texture with very interesting and important results. Other panels have been built to test out interior ventilation of walls, and many other points have been studied.

Fire resistance of various masonry constructions.* HARRY D. FOSTER†. This paper contains a discussion of fire-test methods and their importance to heavy clay products manufacturers, bringing out answers to such criticisms as were recently made by the Common Brick Manufacturers Association. The fire-resistance periods of all masonry constructions including stone, concrete, concrete block, cinder concrete, haydite concrete block, brick, concrete brick, sand-lime brick, structural clay tile of various sizes, designs of unit and resulting constructions, porous clay blocks, plasters, and various other light partitions such as plaster on wood lath and wood studs with discussions on each showing how and why these various materials are able to attain their respective periods. Periods given in this paper were obtained from various publications as well as from original test data.

Earthquakes and masonry construction.* NORMAN W. KELCH. The effect of earthquakes on various types of structures has been widely discussed and opinions regarding the ability of masonry construction to resist damage by earthquakes have been expressed, not only by those qualified, but by persons of eminence and authority in other matters wholly unqualified to discuss this subject. To separate opinions from facts, a study has been made of actual records of experience and of authoritative engineering data on the subject of earthquakes and their relation to building construction and a comprehensive survey has been made of the damage to all types of buildings in the San Francisco earthquake and fire of 1906; of the Japan earthquake and fire of 1923; of the Santa Barbara earthquake of 1925. It has been found that the monetary loss to building construction caused directly by earthquake has been greatly exaggerated and that in the three outstanding diasters referred to it has amounted to only from 5 to 10% of the total value of the buildings in those areas. It has been found that buildings constructed of brick, tile, and terra cotta have, on the whole, given remarkable records of stability in earthquakes and what is commonly known as "good construction" has a margin of safety against damage from such forces. It was also found that failures of buildings constructed with clay products have been due to a disregard for the proper use of the material or to violations of fundamental construction principles.

Partial literature reference on masonry. 1930 PROGRAM, AMERICAN CERAMIC SOCIETY.—A bibliography of references on masonry compiled for the use of the Masonry Program at 1930 Meeting of the AMERICAN CERAMIC SOCIETY, Toronto, Canada, Feb. 16–21, 1930.

Apparatus for rapid accurate measurement of test specimens.* HARRY D. FOSTER. A piece of apparatus built by F. for tests is described. This is being used by the Ohio State Univ. Eng. Expt. Station for such purposes.

Weathering of building materials. ANON. Dept. Sci. Ind. Research [London], *Rept. Bldg. Research Board*, No. 7 (1928).—The deterioration of building materials under the action of weathering agents and remedial measures have been investigated. The principal causes of deterioration are as follows: (1) *Efflorescence.* This generally originates in the jointing material and consists essentially of alkali sulphates. Cement mortars are more liable to produce efflorescence than are lime mortars, although

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†See also H. D. Foster, "Significance of the Standard Fire Test to Heavy Clay Products Manufacture," *Bull. Amer. Ceram. Soc.*, **8** [12], 351–55 (1929).

lime mortars are not always immune. The addition of trass to cement does not prevent efflorescence. In panels in which sand-lime brick are used no efflorescence appeared. On some materials efflorescence causes little damage but some building stones are materially damaged. (2) *Distribution of Moisture.* Soluble salts may be initially present in some building materials, derived from outside sources such as the soil or formed by decomposition of the material on exposure to the atmosphere. The crystallization of these salts near the surface due to capillary movement and evaporation is a major cause of decay. (3) *Selective Decay.* A material which normally weathers well, may disintegrate rapidly when used with another material, *e.g.*, sandstone with limestone and limestone with magnesian limestone. Deterioration of this type is due to transfer of salts from one material to the other through capillary movement or direct washing by rain. (4) *Biological Agencies.* The action of bacteria, lichens, and mosses are being investigated but no evidence is yet available to indicate that either of these agencies produce any appreciable decay. (5) *Calcium Sulphate.* The action of sulphur compounds which occur in the air has two effects on calcareous building materials: (1) the formation of a hard impermeable skin of calcium sulphate and sulphite which blisters and breaks away from the stone; or (2) the breakdown of the interior structure of the stone. Under modern conditions sulphur gases are the dominant cause of the decay of calcareous building materials. (6) *Frost Action.* Frost does not appear to be a very common cause of stone decay in England. (7) *Remedial Measures.* Surface treatment of experimental test pieces and examination of buildings thus treated indicate that the treatments have had practically no influence in preventing surface erosion and in some instances there is evidence that such treatment has accelerated surface blistering. Steam cleaning of buildings is very effective and if properly manipulated is to be recommended. The use of alkalis in steam cleaning is to be discouraged since these materials readily absorb sulphur gases and cause subsequent efflorescence. Chemical processes of cleaning are detrimental. Washing buildings at regular intervals with water is the most effective means of keeping stonework clean and of retarding decay. W.L.

Origin and effect of soluble salts on clay products. ANON. Dept. Sci. Ind. Research [London], *Rept. Bldg. Research Board*, No. 47 (1928).—The majority of cases of efflorescence in brick and clay products consists essentially of sodium sulphate, in a few calcium sulphate is dominant, while occasionally magnesium sulphate is the major constituent. The common sources of these salts are (1) the material itself, (2) the mortar or backing, (3) the soil, or (4) impurities in the atmosphere. The soluble salts contained originally in the brick may arise from (1) the raw clay, (2) the tempering water used in preparing the clay, or (3) from sulphur fumes absorbed during firing. In some types of ware these may be reduced by the addition of barium salts during manufacture. Several cases of failure of plaster and cement renderings on walls have been traced to the leaching out of sulphates originally present in the brick. W.L.

Scum and efflorescence. L. A. PALMER. *Clay-Worker*, **92** [6], 436 (1929); a reply to the discussion by Ellis Lovejoy in *Clay-Worker*, **92** [5], 347–48 (1929); see *Ceram. Abs.*, **9** [1], 33 (1930).—P. takes some specific statements made by L. and discusses them, raising the question as to whether some of them are not merely assertions which should be backed by experimental data. Some points of agreement with L. are also enumerated while clearing up points of variance. The use of gypsum in Portland cement and the effect of its removal on results obtained is explained. E.J.V.

Absorption and strength of commercial sand-lime brick. H. F. MCMURDIE. *Rock Prod.*, **32** [24], 67–71 (1929).—Measurements of absorption and of transverse and compressive strengths have been made on brick obtained from 25 different commercial

producers of sand-lime brick. The maximum, minimum, average, and distribution of the values obtained and the relations between the various factors are recorded. W.W.M.

Compressive strength of clay brick walls. ANON. *Jour. Franklin Inst.*, **208**, 556 (1929).—Strength tests were made on 168 walls of common brick, each 6 ft. long, 9 ft. high, and on 129 wallettes, about 18 in. long and 34 in. high. Varying kinds of brick, mortars, workmanship, curing conditions, and masonry (solid and hollow) were used. The average strengths of solid walls built with brick having a compressive strength of 3280 lb./in.^{2} were (1) with lime mortar 287 lb./in.^{2}, (2) cement-lime mortar 587 lb./in.,^{2} and (3) cement mortar 661 lb./in.^{2} See also *Ceram. Abs.*, **8** [12], 883 (1929). (*Trans. Ceram. Soc.* [Eng.])

"Sulphur" in glazed brick. ANON. *Brit. Clayworker*, **38** [452], 329–30 (1929).—The earliest investigations of the cause of sulphuring were made by Seger, who found that sulphurous gases from the fuel in the presence of lime, etc., in the clay or glaze produce sulphates which crystallize but do not fuse, and so dull the glaze. These sulphates are difficult to reduce and consequently remain in the glaze. It is sometimes thought that "sulphuring" is due to coal or similar matter in the body of the brick, but this is a mistake. One of the chief causes of sulphuring is the use of coal containing pyrites or other sulphur compounds; these form volatile sulphur compounds which become mixed with the kiln gases and so come into direct contact with the glazed brick. The most critical temperature for sulphuring is about 600 to 900°C when constituents of the glaze begin to decompose. The effect of sulphur on glaze appears to be twofold: (1) if there is an ample supply of air in the kiln the sulphur is oxidized and forms sulphates in the glaze which lead to "blinding" dullness and other well-known defects, and (2) under reducing conditions, polysulphides may be formed and produce a yellow or brown discoloration. The use of fuel which contains sufficient sulphur to harm the ware should be avoided and in addition a reducing atmosphere toward the end of the burn should also be avoided. R.A.H.

Light-weight clay products. ANON. *Brick Clay Rec.*, **75** [13], 807–808 (1929).—Charles Weigel of the Clay Products Co., Dickinson, N. D., has perfected a process for the making of clay products that are from 35 to 65% lighter than standard weight, have high insulating value, are cellular in structure, soundproof, and have fine acoustical properties. The porosity and cell size of the product is controllable. The product may be made with extremely fine cells and glazed with a smooth even surface in practically any ceramic color. One possibility for this product and process is the manufacture of a face brick with a hard-fired dense face, $^1/_4$ or $^3/_8$ inch thick, backed by a porous body weighing but 35% of what a standard fired clay body would weigh. The process of manufacturing has not been disclosed but it will require no change in present methods of manufacturing brick and tile. It cannot be used with all clays, particularly not with surface clays. E.J.V.

Highly porous light-weight brick. W. D. RICHARDSON. *Clay-Worker*, **93** [1], 43 (1930).—A general review of the production of light-weight brick in Germany by the mixing of coal dust or coal slack with clay is presented. No special difficulties are encountered but some special equipment for drying and pulverizing the clay and fuel is needed. In the production of light-weight brick, as done by the Structural Clay Tile Assn., at Roseville, Ohio, there are some particular difficulties which must be overcome before commercial production is feasible. Some experiments with making light-weight brick by adding from 25 to 75% of lignite to clay performed in 1917 by R. are discussed. E.J.V.

Hollow brick closed on five sides. ANON. *Tonind.-Ztg.*, **53** [92], 1617–18 (1929).—The "Avan brick" named after its inventor, Avanzini, is one hand brick measuring

25 x 12 x 14.2 cm. and weighing about 5 kg. It belongs to the group of five-sided hollow brick made by boring instead of stamping. Two holes are bored part way through ordinary whole brick by a specially constructed boring machine. M.V.K.

Hollow brick for floors. ANON. *Rev. mat. constr. trav. pub.*, No. 242, pp. 240–42B (1929).—Concrete is used to fill in the spaces between the brick. A.J.M.

Modernistic brickwork. ELSIE C. BROCKHOFF. *Clay-Worker*, **93** [1], 25–27 (1930).—The modernistic trend has found its way into the residential building field, and brick because of its versatility lends itself well to this style of architecture. Illustrated. E.J.V.

Modernize the clay plant. ANON. *Clay-Worker*, **93** [1], 64 (1930).—In keeping with the modernizing trend now in vogue, clay plants should begin by modernizing in the matter of machinery and equipment, followed by the buildings and all the structural parts of the plant. Finally, there is the matter of modernizing the office, its equipment, and work. E.J.V.

Resurfacing pavements with vitrified brick. H. G. SOURS. *Clay-Worker*, **93** [1], 40–42 (1930).—Some of the resurfacing work which has been done in Summit County, Ohio, is described in detail. After an exposition of the nature of the work done, methods of construction concerned with the curb, patching and leveling depressions, concrete base, preparation of the bed, laying of the brick, rolling the brick, and filling are discussed. Costs compiled from prices bid on work are quoted. Conclusions and recommendations based on the experience gained in this work are advanced. E.J.V.

Standard size brick in Canada. ANON. *Clay-Worker*, **93** [1], 66 (1930).—Plans for the adoption of a standard size brick are under way in Canada. The Ontario Assn. of Architects recently took the initiative by fixing the standard size at 8 by $2^1/_2$ by $3^3/_4$ inches. E.J.V.

Brick for paths. ANON. *Christian Sci. Mon.*, **22** [23], 8 (1929).—Brick, when laid in the herringbone pattern used in many old English cottages, are particularly effective. A brick path is economical and easily laid, the main precautions necessary being that the ground be well-rammed so the brick do not sink; only well-fired brick should be used. E.J.V.

Variety and dependability in use of common brick. ANON. *Christian Sci. Mon.*, **22** [23], 8 (1929).—The effect of the use of skintled brickwork has been to draw attention of the architects to common brick. Common brick, the oldest man-made building material, are better and harder fired, more durable, less absorbent, and stronger than ever before besides offering a wide variety of colors. Brick is unsurpassed in its fire resistance, resistance to heat and cold, and economy of upkeep. It needs no insulation, will not transmit dampness, insures a dry wall, and has good load-bearing capacity. In England, France, and Italy homes are in use today after more than 600 years of constant use. E.J.V.

The face-brick industry. GEORGE P. ANDERSON. *Brick Clay Rec.*, **76** [1], 44–46 (1930).—An analysis of the face-brick industry shows that most of the manufacturers and dealers have failed to operate on a profitable basis except during abnormally prosperous periods. There is a lack of organization in the industry. Little attention has been paid to sales. It is suggested that the marketing of face brick would be greatly benefited by a change from billing per thousand brick by a price per square foot. E.J.V.

Hollow tile for construction with brick or stucco veneer. ANON. *Christian Sci. Mon.*, **22** [33], 9 (1930).—Hollow tile as a building material for residences has grown in favor in recent years as it is a "permanent" type of construction, yet effects economies over other forms of masonry. Each tile has several voids or cells which form long troughs of "dead air," acting as an effective insulator. There are several kinds of hollow

tile. Each type has its own advantages and drawbacks. Hollow tile made of clay with a finished texture face also may be obtained in many colors, from black to light yellow, including reds and greens. These need no exterior finish. One of the chief assets of hollow tile is the fact that the outer surfaces will take whatever exterior finish the builder desires, if the proper type of tile is selected. Some pitfalls to be guarded against are listed. The precaution of "buttering" the ends of the tile is explained and it is urged that the inner surface of the sidewall be furred before any plastering is done on it. Illustrated. E.J.V.

Tile and flooring. ANON. *Clay-Worker*, **92** [6], 459 (1929).—Two kinds of clay tile are used in flooring: (1) hollow or structural clay tile and (2) face tile. Although architects are striving for thinness, less waste space in both floors and walls, they also are demanding more load-bearing strength and fire-resisting qualities. There are good opportunities to extend the use of this tile in flooring, especially for skyscraper buildings. In face tile there is a wider interest, especially on the part of home builders, for both floor and wall work, particularly in bath rooms and kitchens. E.J.V.

Hudson River brick manufacturers. ANON. *Brick Clay Rec.*, **75** [14], 870–82 (1929).—In 1929, three plants were built, which typify the progress in manufacturing methods in the biggest eastern brick production district. These plants are the Excelsior Brick Co. (Haverstraw), Brockway Brick Co. (Beacon), and the Empire Brick & Supply Corp. (Newton Hook). All these plants are completely electrified and have the following features: (1) operate two large capacity automatic soft-mud brick machines with mechanical handling to steam driers, (2) mechanical handling from driers to kilns, (3) machine setting of brick in kiln, (4) machine unloading from the kiln directly onto barges or into container cars on switch tracks running into the kilns, and (5) kiln buildings of structural steel covered with protected metal which is resistant to acid gas. Each plant is described in detail. Illustrated. E.J.V.

Improvement of shape of building brick. ANON. *Tonind.-Ztg.*, **53** [81], 1444–46 (1929).—Greater economy and efficiency in building can be obtained by improving the form of building brick from the standpoint of (1) reducing the weight so that a less strong foundation is necessary, (2) greater insulating properties which would reduce the cost of construction as the walls could be thinner. This would give not only a larger dwelling space but heating would be cheaper. Experiments have shown that with an outside temperature of −20°C, a wall of not less than 50 cm. thickness is necessary to maintain an inside temperature of 20°C without excessive heating. (3) Increasing weather-proof properties of walls by using a larger brick and reducing the number of mortar connections, as mortar is more easily penetrable by moisture, and dampness lowers insulating capacity. M.V.K.

Making brick at Alton. ANON. *Clay-Worker*, **92** [6], 417–27 (1929).—Finding through its sales work that there was a growing demand for color, an insistence for an even wider range than had been previously secured, and knowing that there was a wonderful acreage of rich clay lands containing materials which, if properly blended, would given them an unusual range in color, the Alton Brick Co., of Alton, Ill., decided to make use of the same through proper segregation and processing. A detailed description of the new face brick unit and segregation department is given. Illustrated. E.J.V.

Malvern Brick and Tile Co. ANON. *Clay-Worker*, **93** [1], 32–34 (1930).—A small but thoroughly modern plant, with an annual production of 32 million high quality face brick, tile, and common brick, is located at Malvern, Ark. A new unit has recently been added. It has a compactness and sequence in operation that assures a great saving in labor and time. The products include gray mat face, smooth grays, velour texture gray, velour texture buff, red mat face, red smooth face, and red common brick. The grays and buffs are made from a white fire clay while other brick are made from a red

firing alluvial clay. The methods of winning and preparing the clays, the equipment, and processing of the brick are described. Illustrated. E.J.V.

New face brick plant. ANON. *Brick Clay Rec.*, **75** [13], 814–22 (1929).—The Alton Brick Co., Alton, Ill., has built a new face brick plant with a capacity of 60,000 brick per day. A new batch weighing system has been installed for the first time in a brick plant, new features of construction have been incorporated to prevent spillage and insure clean and continuous operation, a complete plant laboratory has been established, and special devices have been applied to insure the highest quality. A detailed description of these special features is given. Illustrated. E.J.V.

Brick manufacturing in Colombia. ANON. *Tonind.-Ztg.*, **53** [94], 1653–55 (1929).—The present state of this industry, the economic conditions, and the great possibilities for the future of brick manufacture in Colombia, because of the richness of the clay deposits, is discussed. Illustrated. See also *Ceram. Abs.*, **8** [7], 501 (1929). M.V.K.

Building forecast for 1930. C. STANLEY TAYLOR. *Brick Clay Rec.*, **76** [1], 26–29 (1930).—A survey of the building industry indicates that 1930 may be the greatest construction year; figures indicate at least a 7 billion dollar year. Part of this sum will be used for clay products. E.J.V.

Comparison of week's wages in German marks for bricklayers. ANON. *Tonind.-Ztg.*, **53** [92], 1625 (1929).—Amsterdam 64.64, Paris 38.67, Vienna 42.47, Brussels 27.90 Prague 31.00, Berlin 70.00, Lisbon 22.80, Rome 33.76, Ottawa 241.92, London 84.49, Stockholm 86.16, Philadelphia 327.60, Madrid 55.22, Warsaw 40.69. M.V.K.

PATENTS

Manufacture of porous brick, etc. HENRY A. STOCKMAR. U. S. 1,740,631, Dec. 24, 1929. The process for the manufacture of porous or light-weight brick or tile, consists in using the refuse of coal washers containing brickmaking material and a variable amount of fuel, bringing the fuel percentage in the refuse to the average required for forming brick, forming the brick, and firing them by their own fuel content.

Automatic brickmaking machine and apparatus. JOHN C. PELTON. U. S. 1,740,711, Dec. 24, 1929. In combination, a trackway, a mold adapted to travel on the trackway, means to deliver product-forming materials into the mold, and means to impart vibrating movement to a section of the trackway thereby to compact the materials in the mold traveling thereupon, the means comprising fluid-containing cylinders arranged in pairs across the section, a pontoon in each of the cylinders, members connecting each pair of pontoons on which the section is supported, and mechanism to vibrate the pontoons and section relative to the cylinders.

Making porous objects. AMBROSE J. MANDELL. U. S. 1,742,515, Jan. 7, 1930. In a method of producing a hard porous object of low thermal conductivity from ceramic materials, the steps which comprise mixing with the selected materials prior to molding in a plastic state, a substance chemically inert relatively thereto, and capable of being made entirely volatile below its melting point and at a temperature lower than that necessary to completely harden the plastic mixture, molding the mixture into objects of the desired shape and size, heating the objects to dry them and to vaporize the added substance without melting it, which in escaping leaves the objects porous, and then heating and firing the objects at a temperature sufficiently high to completely harden them.

Brick press. LOTT D. OLIVER. U. S. 1,742,555, Jan. 7, 1930. A mold for forming plastic material including a mold box, a movable bottom therein, a plunger opposed to the bottom, inwardly extending means associated with and movable with the bottom and adapted to form a depression in the molded material, the means being movable relative to the bottom to permit its withdrawal from the depression, means for elevating

the bottom and means to lift the molded material from the box, and means for retarding the movement of the depression-forming means relative to the bottom as the bottom is elevated.

Pallet-laying device for brick machines. HARRY W. BRAINERD. U. S. 1,742,845, Jan. 7, 1930. A brick machine having a table adapted to support a series of brick molds, in combination with a pair of supporting members arranged above the ends of the table and adapted to support a pile of pallets, and means for ejecting the lowermost pallet from the supporting members in the longitudinal direction of the pallet.

Refractories

Cold crushing strength of fire brick. HIMANSU K. MITRA. *Jour. Amer. Ceram. Soc.*, **13** [2], 85–97 (1930).—Data on cold crushing strength in three directions, *viz.*, flat, edge, and endwise of six brands of fire brick are given. Transverse strength data of all these brands are also given. Porosities of all the brick used in these tests were determined by the air-expansion method. The purpose of the investigation was to find whether it is possible to translate the values obtained for crushing strength of fire brick in one direction (flat) into values for the other directions (end and edge); to determine whether transverse strength data can similarly be transformed to crushing strength data and vice versa and whether porosity and crushing strength of fire brick are correlated. The data herein presented do not show the existence of any such simple mathematical relationship between the different properties of the brick. A new capping material, a mixture of sand and molten sulphur, was used for the crushing tests, and was found to be more satisfactory than the other materials commonly used for the purpose. It is recommended that in reporting crushing strength data of fire brick, the brick be tested on end.

Fireclays: Their fundamental properties at several temperatures.* R. A. HEINDL. Such properties as modulus of elasticity, transverse strength, porosity, plastic flow, and thermal expansion of 26 fire clays representative of all important deposits in the United States, were studied at atmospheric temperature, 550 °C and 1000 °C. The properties of these clays after firing to cones 4 and 15 are compared.

Thermal expansion of silica brick and mortars.* SANDFORD S. COLE. Thermal expansion from 20 to 950 °C and physical data of silica brick from various producing districts in the United States and Europe are presented. The variations in thermal expansion of brick from various parts of kilns are given for plants in the United States. The variations in thermal expansion of silica mortars from various producing plants are also shown. Data on the effect of size of grain, clay content, and P.C.E. on the thermal expansion of mortars are given. An extensive bibliography on thermal expansion of silica brick appears with the paper.

Refractory clay deposits of northern Ontario.* W. S. DYER AND R. J. MONTGOMERY. The refractory clays of northern Ontario are of Cretaceous origin and occur in the basin of the Moose river which empties into James Bay. They include a certain amount of kaolin associated with silica sand, mottled red, brown, and white impure kaolin in commercial amounts and rather extensive beds of dark carbonaceous fire clays. The kaolin varies from white to light buff when fired. The silica could be used for glass sand if washed and graded. The mottled clays vary from cones 27 to $32\frac{1}{2}$ in refractoriness depending largely upon the silica content and the dark fire clays vary from cones 10 to 32 in refractoriness, ranging from a stoneware clay to No. 1 fire clay.

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*Paper presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Toronto, Ont., February, 1930. When this paper is published reference will be given.

Progress report on abrasion test for refractories at high temperatures.* JOSEPH B. SHAW, GEORGE J. BAIR, AND MYRIL C. SHAW. The senior writer of this paper is Chairman of the Sub-Committee on Refractories of Committee C8 A.S.T.M. Much work on this test has been done by Mr. Brady of the U. G. I. Company, the most recent of which was the development of a sandblasting test which has some promising features. It is feit, however, that a test capable of more positive standardization must be devised in order to classify refractories accurately at high temperatures. The present report, therefore, covers the progress made thus far in development of an entirely new type of testing device. The principle involved is actual abrasion by means of a chisel actuated by an air hammer and producing variable degrees of deterioration of the refractories depending upon temperatures and qualities of the refractories.

New developments in field of silicate refractories.* C. L. FREDERICK, JR. New developments in the field of silicate refractories include greatly improved refractoriness and a high development of desirable qualities in silica refractories manufactured from Sharon conglomerate. This paper touches briefly upon the nature of silica refractories in general, with a résumé of materials utilized in the manufacture of silica brick in the United States. Service illustrations of this new refractory are included, as well as interesting test data.

Observation on use of silicon carbide in clay bodies.* S. F. WALTON AND E. L. HAUMAN. In these studies the distinction is made between silicon carbide in a clay body and clay-bonded silicon carbide. Increase of strength by replacement of grog particles was noted. Tests were made on various bodies containing as little as 10% SiC by weight and up to 67% by weight. Comparison of clay and grog bodies, clay grog and SiC bodies, and clay and SiC bodies were carried out under load span test at various temperatures. Commercial application of SiC and clay bodies was discussed.

Small gas-fired laboratory furnace. F. H. NORTON AND C. L. NORTON, JR. *Jour. Amer. Ceram. Soc.*, **13** [3], 16–166 (1930).—There is described a small furnace, particularly suitable for experimental work in ceramics. This furnace is unique in that temperature sufficiently high for nearly all operations in ceramics can be obtained by the use of a standard Méker burner. The temperature can be brought up rapidly and can be held steadily. The construction of the furnace makes it comparatively simple and inexpensive. The increase of conductivity of bodies containing SiC is apparent. Resistance of bodies containing SiC to the corrosion effect of various slags, particularly iron oxides with alkalis and alkaline earths. A comparison with clay grog bodies is given.

Refractories and refractory cements for non-ferrous foundry.* H. E. WHITE. Development in refractory linings for the various furnaces encountered in the non-ferrous foundry industry is outlined, and figures given showing the present trend. These include open-flame, crucible, and electric furnaces. The open-flame furnaces formerly used firebrick linings, but silicon carbide and high alumina refractories are coming into use. The crucible furnace linings show a decided preference for silicon carbide refractories, while the electric furnaces are partial to the alumina and mullite bearing types. Progress in the manufacture of refractory cements and their use in the various types of furnaces is discussed. Data are given which indicate that the use of the proper types of cements for maintaining furnace linings of similar composition is becoming more general.

New method for testing refractory cements. CHARLES MCMULLEN. *Jour. Amer. Ceram. Soc.*, **13** [3], 171–73 (1930).—A new test for refractory cements is described in which the modulus of rupture of test bars made of the cement is determined at different

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temperatures and plotted as a curve. The resulting curves predict the performance of cements in service. A photograph of the apparatus used is shown.

Electric spalling furnace. HENRY N. BAUMANN, JR. *Jour. Amer. Ceram. Soc.*, **13** [3], 167–70 (1930).—An electric spalling furnace, heated by means of a graphite resistor and holding twelve test brick at a time, is part of the equipment for the routine testing of refractories in the Research Laboratory of the Carborundum Company at Niagara Falls, N. Y. It is more compact, more easily handled and repaired, more closely controlled, free of flame impingement and much to be preferred to the fuel-oil fired type of furnace which it replaced.

Progress report on checker brick investigation.* R. M. KING. Results of laboratory tests on porosity, P.C.E. values and heat conductivity of a number of $10^1/_2$-inch checker brick and 9-inch straights are given in this report. Brick from Ohio, Pennsylvania, Missouri, and Kentucky, and made by three different processes were tested. These tests are preliminary to service tests now being made in steel and glass furnaces. Data on tests are given and relation between results and method of manufacture are discussed.

Chrome brick.* GILBERT E. SEIL. Deposits of chrome ore, more or less important industrially, are found in many parts of the world. The more important ores are named, and the general geological formations of the deposits are described. The various uses of chrome ore as refractory material are enumerated, and the fact that each usage demands definite physical properties is explained. Chemical analyses of sample from the more important deposits are shown, together with microphotographs, proving that the chemical analysis is purely indicative of the value of the ore as a refractory, and that the mineralogical composition of the ore is the deciding factor in the preparation of the ore for the refractory industry. Apparatus for the careful and accurate measurement of the physical changes which take place during firing, due to chemical or physical phenomena, or both, are shown, and methods for determining the temperature at which each change takes place, and the magnitude of each change, are fully described.

Evolution of mullite refractories (including service records).* T. S. CURTIS. The development of the stable structure in silicate refractories is unfolded by means of a motion picture which delineates the formation of crystals, their importance in the final body, and also the plastic flow of refractories, which flow is a function of the crystal-glass relationship. The development of superior load-bearing and slag-resisting properties in a composition that is physically inert is brought out. Natural color photomicrographs depict the structural phases of commercial mullite bodies while the influence of slags is shown through cut sections. The paper closes with a tabulation of statistical records of commercial service on several million mullite brick.

Forming pressure of dry-pressed refractories. Part I. Variation of properties of green brick due to various pressures.* R. E. BIRCH. Making use of a hydraulic press which presses standard fire brick, eight commercial mixtures were investigated to determine the effect of varying the forming pressure. To obtain pressures higher than those used commercially it was necessary to reduce the moisture content. The bulk density of unfired brick is shown to have increased directly with the pressure, as did the transverse strength. These changes, however, are lessened at the higher pressures. By comparing the green bulk density of brick formed on commercial, mechanically actuated presses, with those pressed hydraulically at known pressures it is concluded that industrial forming presses are operated at comparatively low pressures. Fireclay bodies do not attain a state of maximum compressibility within the limits of the study, but continue to contract with additional pressure. **Part II. Spalling and other fired**

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properties of dry-press brick as affected by variation of pressure.* Laboratory tests of the dry-pressed fire brick reveal that fired porosity varies inversely with the forming pressure. The change, however, is less marked at high pressures. The resistance to thermal spalling is considerably lowered by increased pressure. The course of spalling is traced for brick of various pressure and density. The relative importance of the various factors effecting spalling loss is discussed. In regard to the load test, increased pressure results in marked improvement with the highly plastic mixtures and more indifferent results when much flint clay is present. In general, firing shrinkage is increased by increased forming pressure, the phenomenon being explained as due to improved continuity of the material tending to further the pyrochemical reactions. The comparatively low pressures of mechanical presses are reaffirmed by a study of fired properties. A summary of the data indicates that by utilizing higher pressures, brick of greater density may be obtained which are greatly improved in appearance, in resistance to abrasion, and in load-carrying capacity, but with diminished resistance to thermal shock. It is indicated that higher forming pressures would partially obviate the necessity of firing ware to the present high temperatures.

Proportioning grain sizes of flint clay in fireclay refractories.* STEPHEN M. SWAIN. This investigation was conducted to determine the changes brought about in the properties of a fireclay refractory by grading the sizes of the flintclay particles. A complete series of mixtures was studied involving (*a*) a Pennsylvania flint clay showing "secondary expansion" characteristics with 12½%, with 20%, and with 30% of the same plastic clay, and (*b*) a Missouri flint clay containing diaspore, with 12½%, with 20%, and with 30% of a Missouri plastic clay. Test pieces, approximately 1½-inch cubes, were made by a semi-dry press process and were fired in a tunnel kiln. The following data were determined on the mixes: moisture required for pressing, volume drying shrinkage, bulk density of both the dried and fired pieces, porosity of the fired pieces, and volume firing shrinkage.

Properties of fineness fractions of slaked semi-flint clay.* M. E. HOLMES AND A. J. PAUL. Manufacturers of semi-flint brick attribute firing defects, in large measure, to a deficiency of the coarsest grains, and the clay is sometimes selected on this basis. It is important, therefore, to have data on the properties of each of the fineness fractions. A select sample of Missouri semi-flint clay was slaked to its natural size of grain and screened into the following sizes: on 20, 20 to 40, 40 to 60, 60 to 100, and through 100-mesh. Each was ground to through 100-mesh, formed into dry-press bars, and fired to cone 14. There was a quite regular increase from the coarsest to the finest fractions in volume drying shrinkage, dry modulus of rupture, and fired modulus of rupture, ranging in amounts from about 100 to 200%. There was a quite regular decrease in fired porosity, fired shrinkage, firing range, and overfiring temperature. The 100-mesh fraction is a very dense firing clay, giving a high dry and fired modulus of rupture, and would be effective as a "dope" for a weak clay. The properties of the intermediate finenesses are substantially an average of the properties of all the finenesses. Points of inferiority in the coarse fractions are supplemented by points of superiority in the fine fractions, and vice versa. All fractions are therefore desirable, and, further indications are that no substantial improvement could be made by screening out any one of the fractions. These conclusions were checked up by a series of test bars in which each fineness was successively removed, leaving all the grains in their natural size. No large effect was produced by eliminating any one fraction, indicating that the gradation in properties was so gradual that any fraction is an effective substitute for the one next in size. This indicates that the practice of judging the quality by the amount of very

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coarse grains is hardly adequate. Eliminating two consecutive finenesses, however, would have an appreciable effect.

Value of research on refractories. ANON. *Brit. Clayworker*, **38** [452], 342–50 (1929).—Discussions were presented at a meeting given under the auspices of the Refractories Assn. of Great Britain by the following: FRANK WEST pointed out that a material may be refractory in one process but break down in another, or a refractory may give good results in the hands of one engineer, but give bad results in the hands of another. The assistance of scientists is essential in determining the composition and properties of such substances. It is also necessary to explore systematically the failures of refractories in use so as to get a better understanding of its conditions which are favorable or inimical to a long life. W. J. REES in his talk considered the subject from two aspects: (1) improvement of the average quality of materials at present available as refractories; (2) provision of new or different types of refractories. He stated that research has greatly benefited the glass trade. The improvement in quality of refractories, such as sillimanite, have unquestionably benefited the glass industry. He also spoke of the possibilities of applying research on refractories to the iron founding industry as well as steel industry with special reference to the refractory used in the high-frequency induction furnace. S. R. HIND discussed the type of individual who could be recommended for research, the different classes of materials available for refractories, the problems confronting the manufacturer of refractories, and the type of tests around which investigations chiefly center. A. J. DALE spoke on the value of liaison in refractories research; there is and will no doubt continue to be some degree of discord or uncertainty as to the type of research which will yield results most beneficial in immediate or ultimate industrial application. For research to benefit industry, it must finally confer some economic advantage; and perhaps, on this account, and also for reasons not unconnected with the contrasting temperament of the academician and the industrialist, two distinct schools of research thought exist. The gap which divides these two schools of thought is wide. Technical research has attempted to bridge the gap between the purely industrial and purely academical. A more definite attention directed toward the establishment of liaison between the respective units might well mean that the manufacturer and user of refractory materials will reap a maximum of benefit in a minimum of time. A. T. GREEN talked on "Some notes concerning research into technology of refractory materials." Further research into the problems concerning the manufacture and industrial usage of refractories is imperative, since the more precise is their knowledge of these materials the greater will be the fuel conservation and economy of high-temperature operations. Going hand in hand with investigations of fundamental properties the definition of the actual conditions obtaining in the use of refractory products is essential. G. pointed out the value of organized research in solving industrial problems. R.A.H.

Heat conductivity of refractories. VLASOV. *Refrac. Jour.*, **5** [51], 124 (1929); for abstract see *Ceram. Abs.*, **8** [12], 891 (1929). E.P.R.

Factors in furnace design. E. G. BAILEY. *Trans. Amer. Soc. Mech. Eng.*, **50** [33], 253–83 (1928).—A brief history of the experiences encountered in the construction and service of furnaces in the past is given. The principal factors that should control furnace designs are (1) complete combustion with a minimum of excess air, (2) controllable rate of combustion over a reasonable range, (3) long endurance of furnace walls, (4) prevention of slag on boiler tubes, and (5) removal of ash. In the entire history of burning coal the development has been along the lines of keeping the furnace walls and furnace bottom at a temperature below the fusing point of the ash in the coal being burned. The most generally used method of limiting the furnace temperature is by excess air. This air is usually admitted where clinker trouble would be most pronounced.

Excessive cooling of the furnace by either excess air or water circulation interferes with proper results. The best performance can be obtained if the air supply can be controlled for proper combustion only, with the furnace as hot as possible, rather than supplying air for the dual purpose of cooling furnace walls and burning fuel. Furnace-wall endurance, reduction of slag on boiler tubes, and removal of ash from the furnace are all closely associated, as they have to do with the molten condition of the ash in suspension in the furnace. While the use of special qualities of refractories is sometimes beneficial in resisting the fluxing action of molten ash, sooner or later the ash will flux, scour, or wash away any or all types of refractories if it is streaming over the refractory in a molten condition. The only positive manner of resisting the molten slag permanently is to reduce the temperature of the wall by absorbing heat at such a rate that a film of solidified slag will be maintained on it. A number of actual installations are discussed. E.P.R.

Some fundamental considerations in design of boiler furnaces. W. J. WOHLENBERG AND F. W. BROOKS. *Trans. Amer. Soc. Mech. Eng.*, **50** [15], 141–58 (1928).—The article deals with the influence of furnace water walls on the furnace volume requirements insofar as flame temperature is the limiting factor in the allowable rates of energy release. It is shown that the totally cold furnace envelope provides for the highest permissible energy-release rate at a given flame temperature. The permissible load range in a furnace for high and low limits of flame temperature is, however, greatest in the refractory-lined water-wall furnace. E.P.R.

Study of crystalline compounds formed in slags on boiler-furnace refractories. T. A. KLINEFELTER AND E. P. REXFORD. *Trans. Amer. Soc. Mech. Eng.*, **51** [22], 347–48 (1929).—The article is a progress report of the work done to date, of the methods used and the difficulties encountered in a laboratory study of the equilibrium relation of oxides composing the slags on boiler-furnace refractories at high temperatures. No data or conclusions are presented. E.P.R.

Laboratory slagging test for boiler-furnace refractories. R. K. HURSH. *Trans. Amer. Soc. Mech. Eng.*, **51** [22], 339–45 (1929).—H. gives particulars of a simulative service test of refractories with coal-ash slag made in a laboratory furnace in which the test brick form the lining of a cylindrical chamber rotated about a vertical axis. Powdered slag or a mixture of slag with powdered coal is fed at a uniform rate through the gas burner which heats the furnace, impinging on the vertical faces of the brick and flowing out through the bottom of the furnace. Temperature and atmospheric conditions are controlled and the test brick receive equal slag treatment. Comparison of slag effect on the refractories is made by volume loss per unit area of exposed surface. Tests have been made with slags representing coals used at five power stations where field tests were conducted, and the results are presented by H. It is also found that the relative effects of these different slags at a furnace temperature of 2900 °F varies with the composition and fusibility of the coal ash. Further, the erosion of the refractory is dependent on the viscosity of the slag and increases in direct proportion to the furnace temperature. Tests made at temperatures corresponding to those in the boiler furnaces produce similar action on the refractories, as indicated by petrographic examinations. The relative resistance of refractories of different composition and physical structure is not the same for different slags. E.P.R.

High ratings obtained in boiler-furnace tests with erosion of refractories. ANON. *Power*, **68**, 839 (1928); *Refrac. Jour.*, **5** [51], 114 (1929).—Owing to the need for more power at their Niagara Falls plant, the Carborundum Co. decided to test in practice the qualities of the silicon-carbide refractory, Carbofrax. A revised design of water-wall was fitted in view of the large increase in the rate of water circulation, and a modified design of the air-cooled front wall to suit the characteristics of Carbofrax, air cooling, and Carbofrax facing for the bridge wall were also provided. The capacity of the fur-

nace remained unaltered; its bottom was trough-shaped with water-cooled walls. The brick were thinner than before owing to the structural strength of Carbofrax. No mortar or cement was used. The boiler rating was increased during a series of trials from about 100% to more than 500%, the limiting factor being the capacity of auxiliaries. Even at the highest ratings it was easy to maintain 14 to 16% of CO_2 in the furnace. At the lower rating the heat released diminished to 10,000 B.t.u. per cu. ft. of furnace volume without hindering combustion or producing smoke. The dryness fraction exceeded 99% at the highest ratings. Much of the ash had the consistency of coarse sand and the remainder consisted of friable lumps which broke into small pieces when handled. On examination after the trials, the refractory was found to be covered with a thin coating of porous slag which had formed almost immediately and served as a perfect protection. On several occasions sheets of slag were peeled off the wall at different points, and in every case the Carbofrax beneath showed a clean, undamaged face. The absence of hard slag in the ashpit was attributed to rapid absorption of heat by the Carbofrax covering of the water-walls. E.P.R.

Cooling refractories in boiler furnaces. I. RALPH A. SHERMAN. *Power*, **70** [18], 675–77 (1929).—Two points are considered: (1) relation of temperature to service, (2) principles of transfer of heat to and from refractory walls. Service life of a refractory wall may often be prolonged if the temperature is reduced by cooling with air, water, or steam. Even though the temperatures attained by refractories in boiler furnaces are below their softening temperatures, they deform under load and are subject to attack by slag. An indication of a certain critical temperature at and below which little erosion will occur, is the temperature at which a pyrometric cone made up of the coal ash will deform. The rate of erosion increases with increase in temperature above the critical point. Thus if the surface temperature of the refractory can be cooled below the critical point, its life may be prolonged. Air or water cooling of refractory walls has other added advantages such as preheating the air for combustion or feed water, making the boiler more efficient. If the design is such that it gives high rates of heat transfer relative to the rate of heat liberation, the furnace temperature is lowered and slagging is reduced. Complete calculations are given for the rate of heat transfer through various refractory materials. Calculations show that the over-all heat transfer coefficient is largely dependent upon the resistance of the refractory material. Values show that a decrease in wall thickness affects the hot surface temperature more than the velocity of the air. **II. Practice.** *Ibid.*, **70** [20], 753–55 (1929).—S. presents results of several experiments in this field, shows the relation of practical to theoretical results, and gives a valuable summary of the effects of these conclusions on the actual construction of furnace walls. (1) Because the greater part of the heat transfer to furnace walls is by radiation, high rates of heat transfer through the wall are necessary to reduce appreciably the temperature of the hot face. (2) To obtain high rates of heat transfer the following things are required: (*a*) use of a thin section of refractory, (*b*) a refractory of high thermal conductivity, and (*c*) a high coefficient of transfer from the cool surface to the cooling medium. (3) The reduction in surface temperature by air-cooled walls is limited by the thickness necessary for strength and to prevent air leakage. Air-cooled walls are limited, therefore, to moderately severe slagging conditions, but they present important advantages. (4) Thin sections of refractory of high thermal conductivity can be used as a refractory facing for water-tube walls, and by proper design a high coefficient of transfer from the refractory to the water can be obtained. Such walls are indicated for severe slagging conditions and they too, present other advantages. O.E.M.

Boiler-furnace refractories. C. F. HIRSHFELD AND W. A. CARTER. *Trans. Amer. Soc. Mech. Eng.*, **50** [33], 115–25 (1928).—This group of materials includes brick and tile, and also the wall mortars, plastic compounds, and so-called high-temperature cements.

A field survey of the conditions to which refractories were subjected in different kinds of service was made along with laboratory investigation such as analyses of fuel and petrographic study of new and used refractories. The work had as its object to determine the chemical and physical phenomena occurring in boiler-furnace refractories and to obtain data to aid in choice of fire brick for specific purposes. Each type of furnace construction, method of firing, variety of fuel, and set of operating conditions calls for a unique solution. E.P.R.

Refractories service conditions in furnaces burning powdered Illinois coal with long-flame burners. R. A. SHERMAN AND EDMUND TAYLOR. *Trans. Amer. Soc. Mech. Eng.*, **50** [15], 125–40 (1928).—This report presents data which pertain to furnace conditions that affect the life of refractories in furnaces burning coal from the Illinois field in powdered form with long-flame burners. The investigation, conducted at the Cahokia, Ill., station of the Union Electric Light & Power Co., and at the East Peoria, Ill., station of the Ill. Electric Power Co., was a part of the study of the boiler-furnace service conditions which govern the life of refractories being conducted by the Bureau of Mines in coöperation with the Special Research Comm. on Boiler-Furnace Refractories of the A.S.M.E. The study of the properties of the refractories which affect their life is being conducted concurrently under the same coöperation by the Bureau of Standards. E.P.R.

Flow of heat through furnace hearths. J. K. KELLER. *Trans. Amer. Soc. Mech. Eng.*, **50** [15], 111–24 (1928).—K. points out the lack of definite knowledge upon which the engineer can base calculations of heat losses through furnace hearths. The solid or nonventilated type of hearth is discussed, and certain conclusions as to relations of heat-flow to shape and construction are reached. An explanation of the methods used in arriving at these conclusions is given. A series of formulas and examples illustrating their use are given for each of the several types of hearths discussed. The question of value and methods of insulation is carefully considered. E.P.R.

Crucible for very high temperatures. ANON. *Chem. Fabr.*, No. 37 (1929); *Tonind.-Ztg.*, **53** [96], 1700 (1929).—The Bureau of Mines has developed a crucible made of magnesia fused by electricity which was mixed with 3% aluminum; after grinding, it was saturated with 7% of a 25% magnesium chloride solution. The firing temperature was 2100°C. M.V.K.

Measurement of heat conductivity of refractory materials at high temperatures. A. EUCKEN AND H. LAUBE. *Tonind.-Ztg.*, **53** [91], 1599–1602 (1929).—The experiments undertaken by the Chemical Institute in Breslau, Germany, are reported and methods of procedure explained. The refractory materials were in the form of hollow globes, outside diameter of 180 mm., inside diameter of 60 mm. Within, by means of an electric heating unit the quantity of heat per unit of time (L) could be measured and controlled. Tests were made at temperatures of 300 to 1100°C. The decrease of temperature was measured at 4 different points by a platinum platinum-rhodium thermo-element. The formula used was $2m = \frac{L}{4\pi}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)\frac{1}{d_1 - d_2}$. The results of these experiments showed that the absolute value of the temperature coefficients of the conductivity of heat for refractory materials diminishes with rising temperature, and at very high temperatures the conductivity seems to maintain constant value. M.V.K.

Progress in fuel utilization in 1929. ANON. *Gas Age-Rec.*, **64** [24], 865–70 (1929).—A partial report of the Fuels Division, A.S.M.E. is given. Although the manufacture of refractories is not altogether a problem of fuel utilization, refractories are such an important part of most combustion equipment that a short summary of the developments in this field is given. During the past year there has been a general adoption of manufacturing methods in refractories which, while not entirely new, would have been

considered revolutionary several years ago. The tunnel kiln has been adopted for firing fireclay, silica, and chrome brick, and many labor-saving devices have been installed. Several new refractories have come into prominence recently, among which are unfired magnesite brick, mullite, sillimanite, and refractory shapes made from a mixture of chrome and diaspore. Diaspore refractories which have been subjected to an unusually high heat treatment are available commercially, and development work is being carried out on the manufacture of light-weight cyanite brick which combine heat-insulating properties with high refractoriness. Progress has been made in the design of special refractory shapes for blast-furnace stoves and open-hearth regenerators. The new shapes are said to result in large gas savings. F.P.H.

Manufacture of firebacks. ANON. *Brit. Clayworker*, **38** [452], 331–33 (1929).—The manufacture of firebacks, *i.e.*, the 3-sided slabs which form the back and two sides of many modern fireplaces, is one of those industries about which very little information has been published. Firebacks have to resist fairly high and sudden changes in temperature. A popular mixture for firebacks consists of one part of grog and 6 to 8 parts of fire clay. Greatly as porosity is desired it is seldom desirable to add coke, cork, sawdust, or other combustible material. The necessity of properly tempering the clay is stressed. The plastic clay is usually shaped in wooden molds of the same shape and size as the front of the firebacks. The use of presses, driven either by hand or power, have not been successful with firebacks. The drying, dressing, and firing processes used in the manufacture of this article are discussed. R.A.H.

Preventing shattered shaft linings. ANON. *Iron Age*, **123** [7], 480–81 (1929).—Laboratory studies to determine the cause of disintegration of blast-furnace shaft brick, plant control, and tests on brick before shipment are described in this article. E.C.C.

Refractory linings. ANON. *Refrac. Jour.*, **5** [51], 117 (1929).—Linings of cement kilns have lasted two years, even when being fired alternately with oil and powered coal, and making both British Portland, and rapid-hardening cements. The material not only offers a high resistance to abrasion owing to its mechanical strength, but also possesses a texture of the right porosity and thus prevents the brick from spalling and the lining from collapsing, even when the kiln is being driven to its utmost capacity. E.P.R.

Character of tank blocks for glass furnaces. P. P. BUDNIKOFF. *Tonind.-Ztg.*, **53** [91], 1603–1605 (1929).—The resistance of tank blocks to the action of melted glass depends not only on chemical composition and homogeneous structure but also on porosity. In tank blocks having too coarse a granular structure, or an unsatisfactory proportion of large grains the quantity of binding clay is insufficient to fill up the spaces between the grains and only coats them. B. gives a detailed description and qualification of materials used and results obtained in his experiments. M.V.K.

High-grade glass-melting pots. D. W. ROSS. *Glas. Ind.*, **37** [15], 215–16 (1929); reprinted from *Fuels and Fur.*, **5** [3], 375–76 (1927); see also *Ceram. Abs.*, **6** [6], 224 (1927). E.J.V.

Corrosive action of glass on tank blocks. S. R. SCHOLES. *Glas-Ind.*, **37** [12], 181–82 (1929); reprinted from *Fuels and Furnaces*, **6** [2], 183–86 (1928); see also *Ceram. Abs.*, **7** [6], 369–70 (1928); **8** [4], 258 (1929). E.J.V.

Refractory brick. TESCH. *Ind. Chemist*, **10**, 422 (1929); *Refrac. Jour.*, **5** [51], 123 (1929).—An illustrated description is given of the Setterberg porous refractory and insulating brick. Tests show that the softening point of the Setterberg brick is 1655°C and the fusion point 1680°C. The brick are widely used as an insulating material for lime kilns, cupolas, etc., and as a refractory material in ceramic and glass furnaces. Owing to its absorptive properties, the brick cannot be used in contact with slags or molten metals. E.P.R.

Silica brick. W. J. Rees and W. Hugill. *Refrac. Jour.*, **5** [51], 123 (1929); for abstract see *Ceram. Abs.*, **8** [11], 814 (1929). E.P.R.

Silica as refractory material. R. B. Sosman. *Iron Age*, **123** [23], 1554–56 (1929); for abstract see *Ceram. Abs.*, **9** [1], 41 (1930). E.C.C.

Developments in manufacture of D.T.S. sillimanite. Felix Singer. *Elektro-Jour.*, 9–10 (1929).—The rapid development of this comparatively new high-grade stoneware material as a medium for the manufacture of high-tension insulators is described. Its physical properties are in no way inferior and in some respects are superior to those of porcelain, with the added advantage that the largest insulators demanded by the electrical industry have been successfully manufactured in a single piece. An illustration shows the limit reached to date, a 220,000-volt one-piece insulator 11 ft. high, and consideration is already being given to the manufacture of a proportionately larger 380,000-volt insulator. F.A.W.

Tamp masses. Anon. *Tonind.-Ztg.*, **53** [89], 1570–71 (1929).—Tamp sand is made up of a small quantity of clay and a large quantity of silicic acid. The small clay content affords a satisfactory plasticity as well as a drying and firing constancy. Tamp masses are being increasingly used in foundries for kettle linings as a refractory covering instead of grog. A good tamp sand should contain 85 to 95% silicic acid and 5 to 10% clay and correspond to cone 31 in refractoriness. It is very important that the clay be in finely-divided and homogeneous form. Tamp sand grains are usually smaller than 0.5 mm.; moisture content 5 to 8%; pressure during manufacture, 7 atm. M.V.K.

Silica refractories for coke ovens. R. Richards. *Proc. South Wales Inst. Eng.*, **45**, 419–61 (1929).—The advantages of silica over fireclay refractories are (1) greater refractoriness under load, (2) resistance to effect of salty coals, (3) higher heat conductivity, and (4) less tendency to spalling. Each stage of manufacture is considered, particular attention being given to "crushing," as this determines the porosity of the finished product. Correct mixing of particle sizes produces a material of low porosity (22–24%), with a consequently higher conductivity and lower impermeability to gases. The constitution of various raw materials and the changes occurring during the "firing" process are illustrated by photomicrographs. The specifications and methods of test applied by a continental firm include refractoriness (with and without load), sp. gr., porosity, and thermal expansion. (*B.C.A.*)

Modern clinker works. Schünhoff. *Tonind.-Ztg.*, **53** [82], 1461–62; [85], 1505–1506 (1929).—Description of clinker plant in Dortmund, Germany, which has complete modern equipment. A special air-drying chamber insures careful and uniform drying. The firing is done in an ordinary ring kiln with a firing channel of 80 m. length. A fine luster is obtained on 75% of the clinker by the special arrangement of the ware and the method of alternating clear and smoky fire. M.V.K.

Ceramic coatings—an outcome of corrosion difficulties in oil cracking. J. C. Morrell and W. F. Faragher. *Chem. Met. Eng.*, **36**, 596–99 (1929).—Those metals and alloys which show the greatest resistance to the destructive corrosion of derived hydrogen sulphide in oil-cracking systems are either inherently unsuitable or too expensive for building the larger elements of a cracking plant. A mixture which has proved suitable for linings consists of furnace cement 60 lb., white silica foundry sand (90% to pass 50-mesh) 30 lb., short-fiber asbestos $1^1/_2$ lb., sodium silicate solution (*d* 1.38–1.42) 1 gal., water $1^1/_4$ pints. This mixture is sprayed on the cleaned vessel to a depth of $^1/_8$ to $^3/_{16}$ in., and is then brushed over with a mixture of furnace cement 6 lb., and sodium silicate solution 1 gal., made to suitable consistency with water. When dried and carefully heated such a lining has proved resistant to corrosion and is of sufficient mechanical strength and tenacity. (*B.C.A.*)

Refractories and abrasives with a zirconium base. Anon. *Corriere ceram.*, **10**

[4], 147 (1929).—This silicate of zirconium ($SiO_2 \cdot ZrO_2$) resists a temperature of 2000°C without expanding or contracting and is not affected by acids or alkalis. It is for the most part abrasive. M.V.K.

Use of Cr_2O_3 in ceramics. P. RENAULT. *Corriere ceram.*, **10** [4], 133–37 (1929).—The sesquioxide is the most important oxide of chromium and occurs rarely in nature in a pure form; it exists in small quantities in certain precious stones as the emerald, ruby, and serpentine. Chromite is the principal mineral of chromium. Several methods for the chemical preparation of Cr_2O_3 are outlined. This compound is used largely as a green coloring for ceramic products giving, in combination with oxides of cobalt, iron, zinc, aluminum, etc., every shade and tint of green desired for hard porcelain. The ruby which contains chromium, on being heated to a very high temperature, changes from red to green but turns red again on cooling. M.V.K.

Cupola refractories. COLIN PRESSWOOD. *Foundry Trade Jour.*, **41** [692], 369–71 (1929).—P. discusses the cost of cupola operation as reflected in the finished materials and the part the refractory lining contributes to it. It is shown that there are widely different results obtained in different cupolas that seem to be operating under the same conditions as to charge, lining, and size of cupola. P. discusses what might be the cause for this variation and encourages technical research on the problem. It is stated that linings are subjected to (1) high temperature, (2) rapidly changing temperature, (3) fluxes such as lime, fluorspar, and silica, and (4) mechanical wear and abrasion. These points and the effect of the furnace gases on the lining with respect to the reduction of ferric oxides to the ferrous oxides which flux readily with silica are discussed. The materials available are silica and fire clay because of their low cost. Silica brick spall badly because of the ill effect of expansion due to the presence of cristobalite so abundant in commercial silica brick. It is stated that it is now commercially possible to make tridymite brick which give good results. Fireclay and silica brick are considered in the light of the following characteristics of refractory brick: (1) chemical analysis which shows proportion of fluxes, (2) refractoriness (cone test and underload test), (3) after-expansion or contraction, (4) reversible expansion, (5) crushing strength and transverse, (6) porosity, and (7) spalling. Chrome brick and sillimanite are discussed. There is also a treatise on rammed linings and patching materials. O.E.M.

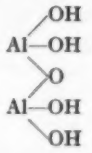
Refractories service conditions in furnaces burning anthracite on traveling grate stokers. R. A. SHERMAN, EDMUND TAYLOR, AND H. S. KARCH. *Trans. Amer. Soc. Mech. Eng.*, **51** [12], 183–96 (1929).—This paper presents data which pertain to furnace conditions that affect the life of refractories in furnaces burning anthracite on traveling-grate stokers. The investigation, which was made at the Nanticoke, Pa., power plant of the Glen Alden Coal Co., is the last of a series of nine in the study of service conditions that govern the life of refractories in boiler furnaces conducted by the Bureau of Mines in coöperation with the Special Research Comm. on Boiler-Furnace Refractories of the A.S.M.E. The study of the properties of refractories which affect their life is being continued by the Bureau of Standards and the Univ. of Ill. A list of the previously published reports of the field investigation is appended to this report. For previous abstract see *Ceram. Abs.*, **9** [1], 43 (1930). E.P.R.

Safeguarding iron and steel and refractories industries. FRANK RUSSELL. *Refrac. Jour.*, **5** [51], 70 (1929).—The extension of the provisions of the Safeguarding of Industries Act to the iron and steel and refractories industries has become a matter of national importance. E.P.R.

Proprietary air-cooled refractory walls. C. S. GLADDEN. *Trans. Amer. Soc. Mech. Eng.*, **51** [22], 273–85 (1929).—G. discusses (1) the evolution of the boiler furnace and the increasing tendencies toward higher ratings of boiler operation and the attendant increasing maintenance troubles with refractories, (2) some of the proprietary air-cooled

walls now available for the consideration of designing engineers and boiler-plant operators, (3) the operating experiences of certain engineers with air-cooled refractory walls of different types, and (4) conditions suitable for air-cooled refractory-wall installations. E.P.R.

Chemical composition of bauxites. ELBER. *Rev. mat. constr. trav. pub.*, p. 234 (1929); *Rock Prod.*, **32,** [23], 93 (1929).—Bauxite is essentially an oxide of hydrated alumina of the formula:

$(Al_2O_3 \cdot 2H_2O)$ or 

In general the bauxites contain 3 to 4% SiO_2, 25 Fe_2O_3, and 3 to 4 TiO_2, the French bauxites contain generally 12 H_2O, and the American bauxites about 30%. The former, with about 75 Al_2O_3 are considered superior. Analysis methods and the determinations of Fe_2O_3, TiO_2, Al_2O_3, CaO are given from the viewpoint of the use of bauxite for fire brick in cement kilns. W.W.M.

Alite (bauxite) deposits of the world. HERMAN HARRASSOWITZ. *Naturwissenschaften*, **17** [48], 928–31 (1929).—Alite is a mineral of practically pure alumina which may be divided into two principal classes: trihydroalite and mono-hydroalite. There is a discussion as to its geological formation and geographical distribution. L.T.B.

Bauxite industry of northern South America. LAURENCE LITCHFIELD, JR. *Iron Age*, **128** [7], 242–49; [9], 346–49; [12], 460–64 (1929).—A comparatively recent development in the British and Dutch Guiana colonies now supplies one-fifth of the world's production of bauxite. The historical outline, topographic details, genesis, and geology of deposits, description and analyses of ores and specifications, and requirements for ores are given. E.C.C.

Basic processes of manufacturing alumina. G. G. URAZOV AND Y. E. VILNYANSKII. *Jour. Appl. Chem.* [Russia], **1,** 271–83 (1928); for abstract see *Ceram. Abs.*, **8** [12], 895 (1929). (*B.C.A.*)

Soda-lime process of manufacturing alumina from bauxite and aluminium silicates rich in silica. G. G. URAZOV, Y. E. VILNYANSKII, AND Y. A. MORACHEVSKII. *Jour. Appl. Chem.* [Russia], **1,** 77–96 (1928); for abstract see *Ceram. Abs.*, **8** [12], 895 (1929). (*B.C.A.*)

Barium process of manufacturing alumina from bauxites and aluminium silicates rich in silica. G. G. URAZOV AND A. V. CHITAEV. *Jour. Appl. Chem.* [Russia], **1,** 96–109 (1928); for abstract see *Ceram. Abs.*, **8** [12], 896 (1929). (*B.C.A.*)

Missouri diamonds. ANON. *Brick Clay Rec.*, **76** [1], 30–37 (1930).—After about fifty years of operation in St. Louis, the Missouri Fire Brick Co., makers of Missouri Diamond brand fire brick, have erected a new plant at Vandalia, Mo. Most of the interest in the new unit centers on the tunnel kiln installation with some of the attention divided between an interesting Diesel engine installation and some modern dry-press machinery. The tunnel kiln, of a capacity of 33,000 a day, has an overall length of 392 ft. and its construction embodies the principle of a semi-open firing in the actual firing zone, direct contact of products of combustion with the ware throughout the preheating zone, and an entirely muffled construction in the cooling zone. Details of various interesting features are given. Illustrated. E.J.V.

Aluminous refractory materials: cyanite, sillimanite, and corundum in northern India. J. A. DUNN. Geol. Surv. India, *Memoirs*, **52** [2], 145–274 (1929).—This investigation of aluminous silicate deposits in northern India was instituted in view of the

considerable value which the ceramic industries have attached to the minerals cyanite, sillimanite, and andalusite in recent years. Sillimanite, in particular, is known to have exceptional properties as a refractory, but up to a few years ago no large deposits had been discovered, although the mineral was known to occur in Germany, France, Scotland, South Africa, Brazil, the U.S., Burma, and Ceylon. The existence of large resources of sillimanite in Assam was made known in 1922, and this was followed by the report of cyanite deposits in Bihar and Orissa. Several misconceptions and much uncertainty arose as to the nature of these deposits, partly because of the earlier reports of the occurrence of corundum in both tracts, and their examination became a necessity. The investigation was in the field program for 1925 to 1926 but through unforeseen circumstances was delayed until 1926 to 1927. Deposits in Assam, Rewa (Central India), Bhandara (Central Provinces), Singhbhum, and Manbhum (Bihar and Orissa) were studied. In this memoir detailed rock descriptions and theoretical geology have been kept apart as much as possible from the more practical information which is the material of greatest interest to those concerned with the mining and industrial application of these minerals. The headings in each chapter are sufficient index to where the practical information may be found. Illustrated.

Fireclay deposits in the Ural. M. GORDIENKO. *Gorny Jour.* [Moscow], No. 4, p. 575 (1929).—G. gives information on fireclay deposits near Okulovsk which have not been described yet, although their commercial value not only for the district of the rural but also for the industry of Central Russia may be of great importance. The deposits are situated at one kilometer distance from the railway station of Okulovsk (Perm Railway line). The exploitation is at the present performed without any system by local peasant organizations. The clay is of high quality; white color, plasticity, and an almost complete absence of quartzite make it very valuable for manufacturing the best melting pots. The latter are used in the Ijevsky gun factory and are considered to be the best in the Ural. According to laboratory tests made in the Ijevsky factories the clay consists of Al_2O_3 from 36 to 38%, Fe_2O_3 from 2 to 3.5%; its resistance to heat reaches 1700°. The thickness of the deposit has not yet been established but it is not less than from 8 to 10 m. The deposit is considered to be of great commercial value. W.A.

Fireclay deposits in Tula. ANON. *Gorny Jour.* [Moscow], No. 5, p. 820 (1929).—An exploration party sent by the Geological Comm. of the U.S.S.R. investigated the deposits of fire clay, sands, and limestones in the province of Tula. Large deposits extending from the city of Rjev to Staritza were discovered. The area of the deposits reached about 150 sq. km. A great glass factory for manufacturing special apothecary glassware will be built at the place of the deposits next year. W. A.

PATENTS

Reactive packing for metallurgical refractories. CHARLES SAMUEL HOLLANDER AND EDWARD LESLIE HELWIG. U. S. 1,741,128, Dec. 24, 1929. The process of blocking egress of a charge in case of a refractory failure of a crucible or retort by surrounding the crucible or retort with a packing which will react chemically with the contents to form a plastic mass at the prevailing temperature.

Circulating air-cooled block. JOHN E. ANDERSON. U. S. 1,741,180, Dec. 31, 1929. In combination with a furnace including a wall and a grate structure, blocks mounted at the inner face of a wall above and adjacent the grate structure, the blocks being provided in their inner faces with horizontal channels, each channel having an upper wall perpendicular to the face of the block and a lower wall inclined downwardly toward the grate, each channel also having a vertical inner wall connecting the upper and lower walls, the blocks being provided with air-admission openings extending through the

inner faces thereof and opening through the vertical walls of the channels, and means for supplying air to the openings.

Heat insulation. CHARLES E. KRAUS. U. S. 1,741,574, Dec. 31, 1929. The method of forming cellular bodies which consists in heating a mixture of clay, bentonite, carbonaceous material, and flux sufficiently to form sealed cells.

Furnace wall. GEORGE W. DAVEY. U. S. 1,741,679, Dec. 31, 1929. A furnace structure comprising a fixed outer wall, an inner lining wall of interlocking refractory blocks, and a plurality of sets of tie brick holding the walls in fixed relation laterally but permitting movement thereof in the general plane of the wall, each such set comprising a single brick fixedly secured in one wall and a pair of bricks fixedly secured in the other, the pair of bricks being spaced from the single brick but movably interlocking therewith one at one face and the other at the opposite face, to provide freedom of relative movement between the walls in any direction in the general plane thereof.

Furnace wall. GEORGE W. DAVEY. U. S. 1,741,680, Dec. 31, 1929. A tie block for a double-wall construction, shouldered on two opposite faces for interlocking sliding engagement with one wall structure, and having, on a face extending between the two opposite faces, engagement means for securing it to the other wall structure constructed to provide clearance for movement in a direction at right angles to the sliding movement.

Furnace wall and baffle. DAVID S. JACOBUS. U. S. 1,741,718, Dec. 31, 1929. A baffle comprising two adjacent tubes substantially parallel to each other and a plurality of blocks disposed between the tubes, each of the blocks having oppositely disposed cylindrical surfaces adapted to engage the tubes, oppositely disposed faces extending between the cylindrical surfaces and forming parts of the opposite faces of the baffle, and two edge surfaces extending between the cylindrical surfaces and adapted to contact with corresponding edge surfaces on adjacent blocks in the baffle, each of the two edge surfaces forming an acute angle with one of the cylindrical surfaces and an obtuse angle with the other.

Method of making refractory composition. THOMAS S. CURTIS. U. S. 1,741,920, Dec. 31, 1929. In the manufacture of refractories, the art of producing mullite comprising melting a mixture of fibrous material of the sillimanite group and alumina.

Treating minerals containing potassium, aluminum, and iron. CHARLES E. ARNOLD. U. S. 1,742 191, Jan 1, 1930. The process of extracting potassium, aluminum, and iron values from siliceous minerals which includes treating with sulphuric acid to bring the ingredients into solution as sulphates, separating the insoluble residue, then precipitating substantially all of the ferric and aluminum sulphates while leaving the potassium sulphate in solution by concentrating the excess acid in the solution.

Metallurgical furnace. FRANCIS A. J. FITZGERALD. U. S. 1,742,441, Jan. 7, 1930. An electric furnace for the production of titanium-nitrogen compounds, comprising a refractory body forming a chamber, an inclined grate arranged at the bottom of the chamber for supporting the charge, and a radiant resistor carried by the body and arranged within the chamber some distance above the charge.

Furnace arch structure. JOHN FRANCIS BOORAEM. U. S. 1,743,108, Jan. 14, 1930. In a furnace arch construction, a plurality of rows of refractory blocks, the contacting faces of blocks in adjacent rows being provided with air passages perpendicular to the exposed faces of the blocks and having their egress ends opening upon the exposed faces of the blocks, each of the blocks being further provided in the structure thereof with an additional air passage extending in a plane at an angle with respect to the first-named passages and also opening at its egress end upon the exposed face of the block, the egress end of the additional passage extending in a direction at right angles to the egress end of the first-mentioned passage, and means for supplying air to the other ends of the passages.

Method of forming refractory structure and article. FRANCIS L. ARENSBERG, ARTHUR J. JACKMAN, AND CHARLES L. JONES. U. S. 1,743,803, Jan. 14, 1930. A method of forming a refractory structure comprising mixing a refractory substance with substantially lamellar particles of oxidizable material and thereafter oxidizing the particles.

Fire brick. W. H. RAMAGE. Brit. 321,188, Dec. 27, 1929. Fire brick are made from a mixture of fire clay and sawdust, preferably hard wood sawdust, in substantially equal parts by weight. The mixture is moistened and molded under pressure, then air dried and fired in a kiln in the usual manner. Preferably a semi-flint clay is employed.

Terra Cotta

Notes on servicing tunnel kiln cars.* H. SPURRIER. A lubricant for car bearings was desired which would furnish maximum protection for the bearings and decrease power consumption as much as possible. The maximum operating temperatures reached by the bearings were ascertained and a suitable lubricant compounded, effecting the desired results. A plan for using the lubricant is presented.

Reactivity test for determining value of barium carbonate as scum preventive.* A. LEE BENNETT AND H. R. GOODRICH. A brief review of the causes of scumming and glaze peeling is given and the usual use of barium carbonate for the prevention of these defects is also outlined. The reactivity test for barium carbonate and a suggested chemical analysis for soluble sulphates are described. Reactivity values of various barium carbonates are reported, followed by a discussion of the practical value of the reactivity test. A specification for barium carbonate is recommended.

Method of measuring strains between glass and ceramic bodies.* H. G. SCHURECHT AND G. R. POLE. A new test was developed for comparing the strains existing between different glazes or other ceramic finishes and bodies. By its use glazes or other ceramic finishes may be fitted to bodies so that they are in sufficient compression to prevent crazing without causing shivering. Heretofore this procedure has been difficult to accomplish in the absence of a precise method for measuring the strains existing between ceramic finishes and the bodies to which they have been applied. It was also demonstrated that this test may be used to compare approximately the relative moisture expansions of different bodies.

Device for measuring relation between drying and shrinkage of bodies.* H. SPURRIER. Curves are shown which coördinate shrinkage and drying; also the effect on drying and shrinkage, of fine and coarse silica, grog, etc.

Study of consistencies of raw terra cotta glazes.* L. D. FETTEROLF. For measuring consistency of glazes there is used a method based on the conception of glazes as plastic materials. Factors affecting initial consistency are discussed. The consistency changes that develop upon aging are studied and some methods of minimizing the spontaneous thinning of glazes are investigated. The results of experiments which aim to determine causes of thinning are reported.

Development in spraying devices.* R. F. GRADY, JR. This paper describes a spraying machine which not only permits very accurate control, but possesses sufficient flexibility to produce all types of mottles.

Stoneware as material for technical practice. FELIX SINGER. Reprinted from *Berliner Tageblatt*, No. 6, June (1928).—The use of this material for technical purposes reaches back 2000 years to the construction of the Roman aqueducts. It is suitable for the manufacture of large and complicated shapes impractical in porcelain or other

* Paper presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Toronto, Ont., February, 1930. When this paper is published reference will be given.

vitreous materials on account of (1) high plasticity, (2) high dry strength, (3) lower shrinkage, (4) lower maturing temperature, and (5) high degree of adaptability to all industrial requirements. The manufacturing process is similar to that followed in other ceramic lines. Considerable progress has been made recently in improving the properties of stoneware.

	1921	1928
Compressive strength (kg./sq. cm.)	4600	7970
Tensile strength (kg./sq. cm.)	106	293
Bending strength (kg./sq. cm.)	370	953
Modulus of elasticity (kg./sq. cm.)	5600	4175
Torsion strength (kg./sq. cm.)	210	230
Torsion strength (kg./sq. cm.)	5600	4175
Ball pressure test	800	1007
Blow-bending strength (cm.-kg./sq. cm.)	1.5	4.7
Loss of weight by battering test (%)	6.5	2.6
Sandblast wear (cu. cm.)	5.0	2.0
Linear expansion coefficient	$4.9/10^6$	$3.5/10^6$
Heat capacity (sp. ht. between 17°C and 100°C)	0.188	0.199
Heat conductivity (k. cal./m.h. °C)	1.2	3.01

Mention is made of special applications of stoneware apparatus to the manufacture of sulphuric, muriatic, and nitric acids and innumerable other technical uses, the latest being a special body for the manufacture of large electric insulators in one piece up to 100 inches in height. Research is constantly being carried on with a view to still further improving stoneware by (1) increasing mechanical strength, (2) increasing heat conductivity and reducing coefficient of expansion, and (3) increasing resistance to chemicals, especially alkalis. F.A.W.

Application of chamotte, stoneware, and porcelain in the chemical industry. FELIX SINGER. *Chem. Fabr.*, **2**, 48–49 (1929).—Chamotte material is used where temperatures exceed 200°C. Corrosion is lessened by selecting a high silica material for acid conditions and a basic material for alkalis. A close-grained material offers less surface for corrosion and increases resistance. Stoneware is used in the industry where absolute resistance to acids is required and for temperatures not exceeding 200°C. Its hardness is a valuable factor under abrasive conditions and its physical properties render possible the manufacture of extremely large pieces; vessels up to 1500 gal. and pipe up to 22 ft. in length. Vessels of larger capacity are built out of stoneware tile set in acid-proof cement in iron shells. Resistance to thermal shock is equal to porcelain in pieces of similar size and shape. The design of large pieces used under such conditions is of great importance. Porcelain is ideally suited for small thin pieces where absence of even traces of iron is essential. It is unequalled for laboratory use. The previously sharply-defined limits of these three materials have in recent years been bridged over by the development of intermediary bodies developed for specific technical purposes. The interchange of ideas and methods has benefited all these industries, and increased their adaptability. F.A.W.

Chemical stoneware as plant equipment. PERCY G. KINGSBURY. *Chem. Markets*, **25**, 387–92 (1929). (*C.A.*)

Standard specifications of acid-proof stoneware. ANON. *Tonind.-Ztg.*, **35** [83], 1478–79; [85], 1507–1508 (1929).—Diagrams are given of different models of seven classes of acid-proof stoneware used in heavy chemical apparatus including flanged conduits, elbows, T's, etc., and kettles, with tables classifying measurements and specifications. M.V.K.

Factors which influence durability of clay materials. I. W. ANGUS MCINTYRE. *Trans. Ceram. Soc.* [Eng.], **28** [3], 101–23 (1929); *Tonind.-Ztg.*, **53** [96], 1700 (1929); for abstract see *Ceram. Abs.*, **8** [10], 752 (1929). M.V.K.

White Wares

Adaptability of various methods to the color-determination of whiteware bodies. WILLIAM W. MEYER. *Jour. Amer. Ceram. Soc.*, **13** [2], 98–112 (1930).—A reliable and convenient instrument is needed to measure the absolute color of nearly white ceramic bodies. Various instruments and methods for color measurement are here described and criticized. Nearly all of them neglect the importance of the source of illumination. A method of color measurement is given, and although the Klett-Ritchie spectrocolorimeter was found to be unsatisfactory for this work, it is believed that the modification of the Pfund colorimeter suggested here would be a reliable and convenient instrument for plant use.

Progress in the elimination of saggers in the firing of glost and bisque general ware and glost wall tile. PHILIP DRESSLER. *Jour. Amer. Ceram. Soc.*, **13** [2], 143–49 (1930).—During the past fourteen years the use of saggers has been largely eliminated in the sanitary-ware industry by the use of cars equipped with permanent superstructures of slabs and posts in muffle tunnel kilns. Methods are described by which saggers can be eliminated for firing general ware and wall tile with corresponding benefits.

Thermal expansion of spinel. ANON. Bur. Stand., *Tech. News Bull.*, No. 152, p. 121 (1929).—The thermal expansion of spinel was obtained on a specimen cut from a brick of commercial grade, which contained over 90% spinel according to an examination made of the material with the petrographic microscope. The sample of spinel had a uniform rate of linear thermal expansion from atmospheric temperature to the temperature at which contraction commenced. Although the maximum expansion, 1.195% occurred at approximately 1510°C, contraction commenced between 1300°C and 1400°C. Between 1510°C and 1800°C the material contracted, the rate increasing directly as the temperature. Two heat treatments of the material to 1800°C caused little change in expansion, it being approximately the same up to 1400°C in both determinations. The maximum expansion, 1.355%, of the reheated specimen was reached at approximately 1730°C. The material commenced to contract slowly at approximately 1400°C and continued to do so until a temperature of approximately 1730°C was reached, after which the rate increased rapidly. The average coefficient of expansion from 20 to 1400°C was found to be 8.6×10^{-6}. No deformation was shown by the material. The permanent contraction after the heat treatments was 1.9%. The material gained 1% in weight due to heat treatments. R.A.H.

English china clay investigation. ANON. Bur. Stand., *Tech. News Bull.*, No. 152, pp. 121–22 (1929).—In the course of an investigation of the physical properties of 17 English china clays, a study of the clays in bodies was included. Body compositions of each of the clays were made of 50 parts clay, 30 flint, and 20 feldspar. Water of plasticity, volume shrinkage, shrinkage water, pore water, bulk specific gravity, and modulus of rupture were made on the unfired bodies. The bodies were fired to 5 different temperatures, cones 3, 5, 8, 11, and 14, and modulus of rupture determinations completed on all of them. The values from water of plasticity, bulk specific gravity, and pore water are very nearly the same for all the bodies, that is 30% for the first, 24% for the second, and 1.54 for the last. The values for modulus of rupture on the fired bodies are somewhat higher for the flint-feldspar-clay bodies than for the flint-clay bodies, due to the fluxing action of the feldspar especially at the higher temperatures. R.A.H.

Practical method of controlling quartz content of feldspar.* JOSEPH B. SHAW. This paper describes a method which the writer developed under the necessity of controlling the composition of a feldspar which occurs in dikes, the quartz content of

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* Paper presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Toronto, Ont., February, 1930. When this paper is published reference will be given.

which varies quite largely from point to point. The material, as it came to the mill, would run from one per cent to fifty per cent free quartz. In order to mill such a product it was necessary to sample the material as it left the jaw crusher, subdivide it into numerous storage bins, and after determining the quartz content of each bin blend them to produce a uniform free quartz content in the finished product. Chemical analysis was obviously too slow and some rapid practical process for determining the free quartz was necessary. This process was devised and used and proved by chemical test to be capable of insuring a quartz content varying not greater than three per cent from day to day.

Standardization of feldspar.* B. C. BURGESS. The situation in the industry is described leading up to the formation of the Feldspar Grinders' Institute, (1) discussion at first meeting shows need of standardization, (2) committee reports to Institute September 21, 1929, (3) conference with Bureau of Standards, (4) proposed Commercial Standard for Feldspar published, (5) meeting (for proposed standards presented at this meeting see *Bull. Amer. Ceram. Soc.*, 9 [1], 11–15 (1930)), in Washington, January 14, 1930, and (6) plans for research and further work in the standardization of feldspar.

Simple method for comparing sub-sieve particle distribution in nonplastics.* M. H. HUNT. A sedimentation for determining sub-sieve particle distribution is described. The apparatus is simple and efficient enough to be used in shop practice. Curves obtained on feldspars and flints as well as other ceramic materials are shown.

Factors influencing use of autoclave in testing wall tile.* R. G. MILLS. A report of preliminary tests in an investigation to determine the effects of various factors in the manipulation of the autoclave for testing wall tile is given. The effect of porosity, pressure, duration of test, slow versus rapid release of pressure, and number of repetitions of test have been investigated.

Transverse strength of ball clay-sand and ball clay-flint mixtures.* L. P. COLLIN. Tests of dry transverse strength on 30 ball clays using mixtures of 50% ball clay, 50% flint, and 50% ball clay, 50% standard silica sand which demonstrate the method adopted as a Tentative Standard and which specified the use of silica sand as the nonplastic is unsatisfactory for determining the dry transverse strength of highly plastic clays.

Transverse strength of clay bars on various spans and cross-sections.* KENNETH M. SMITH. The attempt is made to show the discrepancies of the strength of clays with the same cross-section, but on 5-inch span versus 3-inch span. The tests also cover bars broken with rectangular cross-section other than 1 inch square, such as $^1/_2$ inch deep by 2 inches wide and cross-section of a bar with top narrower than bottom and vice versa. The work was done on one domestic and one English ball clay.

Expansion of raw clays.* C. W. PARMELEE AND C. R. AMBERG. The work on this subject was done at the Department of Ceramic Engineering of the University of Illinois in connection with an investigation for the Utilities Research Commission. The thermal expansion of 18 representative clays has been examined over the temperature range 20 to 900°C by means of the Fizeau-Pulfrich interferometer. Also the effect of non-plastics on the thermal expansion, the effect of different initial water contents, and the expansion of some of the other hydrated alumina-silicates have been determined. The results show distinct types of curves into which clays of similar characteristics fall. The endothermic reaction near 500°C and the exothermic reaction near 900°C, previously determined by heating curves, show up as marked breaks in the slope of the thermal expansion curves.

Investigation of possible use of certain California clays in sanitary-ware bodies.

* Paper presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Toronto, Ont., February, 1930. When this paper is published reference will be given.

W. F. DIETRICH AND W. W. MEYER. *Jour. Amer. Ceram. Soc.*, **13** [3], 202–17 (1930).—A bonding clay from Riverside County, a plastic fire clay from Placer County, and a washed, white-firing clay from Amador County were tried in vitreous china sanitary ware bodies. Descriptions and properties of the clays are given. Twenty trial bodies were tested. The bonding clay and the plastic fire clay were found unsatisfactory for use in this class of ware. Based on laboratory tests, the use of the washed clay from Amador County, to the extent of 10 to 30% of the body mixture, is quite feasible. This would reduce the total production cost of ware manufactured in California plants by 1.0 to 2.5% depending upon the location of the consumer and the proportion of local clay that can be utilized. A body containing 30% of the washed California clay and no English china clay proved to be as good as the standard type body used for comparison; while another mixture, containing 18% of the washed clay, was superior in many respects to the standard body. The effects of additions of ground biscuit, magnesium and calcium carbonates, and sodium chloride were also determined. Subsequent commercial tests in a whiteware plant showed that under the conditions prevailing in that plant, from 10 to 15% of the California clay was the maximum that could be used without increasing the vitrification temperature of the body. In this case, the California clay displaced a mixture of china clay and ball clay rather than the china clay alone. It was also necessary to slightly alter the silica-feldspar ratio.

Moisture determination, a shop practice. C. L. DEEDS. *Jour. Amer. Ceram. Soc.*, **13** [3], 200–201 (1930).—A method of determining moisture in crude clay from data on specific gravity of the clay dried and of slip when blunged with definite clay-water proportions.

Gypsum plasters in ceramic industries.* J. E. WISS, T. C. CAMP, AND R. B. LADOO. This paper deals with manufacture, properties, and uses of gypsum plaster in the various branches of the pottery industry, *i.e.*, in white ware, stoneware, electric insulators, sanitary ware, etc., in the terra cotta industries, in plate glass, and for sundry minor ceramic uses. The methods of producing calcined gypsum are briefly described and then follows a discussion of the physical and chemical properties of the three principal forms of calcium sulphate as used commercially, (1) crude gypsums, (2) calcined gypsum (gypsum plaster), and (3) gypsum casts of set-up gypsum plaster. The proper methods of mixing, blending, and casting plaster are described with graphs showing effects of varying such factors as consistency, mixing time, etc. Methods of testing plasters are briefly discussed. Considerable attention is given to difficulties commonly encountered in the use of plaster with causes and methods of correction. This included the use and abuse of plaster molds such as "rotting" of molds, "burning" of molds, efflorescence, etc. The properties of gypsum plaster can be varied within wide limits to meet special requirements. It is shown how the plasters used for pottery and terra cotta molds are quite different from those used in bedding plate glass. The purpose of the whole paper is to give a more complete picture of how gypsum plaster may and should be used in the ceramic industries.

Substitution of inert aggregates for quartz in ceramic bodies.* T. S. CURTIS. A general discussion of the structure of ceramic bodies bringing out the relationship existing between non-plastic and plastic components. The properties developed through the substitution of inert fibers, and also those developed by the typical mullite-forming minerals, are treated upon. A dissertation upon the importance of the glass phase and the use of special fluxes with stable aggregates is included. The paper is illustrated with many natural color lantern slides depicting the structures resulting from the modification of the ordinary triaxial body.

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Effect of different oxides on constitution of porcelain.* A. H. FESSLER AND HANS NAVRATIEL. This article deals in a general way with the glass phase in siliceous porcelain. The influence of different fluxing oxides on the formation of this glass phase is indicated. These oxides may be divided into two groups, one for the alkalis and the other for the alkaline earths although both seem to arrange themselves according to their position in the periodic table in the amount of glass that one mole of the oxide is able to form by solution. This arrangement was indicated by solubility experiments as well as by microscopic and specific gravity determinations.

Effect on high-fired porcelain of adding unstable non-plastic ingredients.* A. H. FESSLER. This article indicates the results obtained by introducing into a porcelain mixture a non-plastic conglomerate, consisting of alumina, silica, and a fluxing oxide which latter has been heat-treated in such a manner that its crystallization has been arrested. Upon subsequent kiln firing, crystallization takes place and the arrested crystals grow, orienting themselves in such a manner as to form a network of interwoven crystals. The effect of this crystallization improves the physical properties of the porcelain.

Method for measurement of viscosity of porcelain.* C. W. PARMELEE AND A. E. BADGER. A torsional method is described and some results given of the study of the viscosity of porcelain in the temperature range 400 to 1000°C.

Progress of fluidity in porcelain bodies.* R. A. SNYDER. Firing characteristics of a group of 13 clay-flint-feldspar porcelain bodies were studied. Firing shrinkage, porosity, and rate of deformation were determined on specimens of all bodies fired at a series of temperatures, thus observing the rate of vitrification and subsequent fluidity of each of the bodies in question. Cross-breaking strength tests were made in order to ascertain the relation of composition and firing temperature to mechanical strength.

Some data of whiteware industry in West Virginia. W. A. KOEHLER. *Bull. Amer. Ceram. Soc.*, 9 [3], 57–60 (1930).—Most of the usual types of whiteware are manufactured in West Virginia by 24 different firms. Data are given on the kinds of body, raw materials used, and their geographic sources; the materials used for glazes; lawn meshes used; number and kinds of periodic bisque kilns and glost kilns; number of car tunnel bisque kilns and glost kilns; hours kilns are on fire and the cones reached in each of the various types of whiteware.

Air conditioning in ceramic industry.* C. E. PARMELEE AND H. B. MATZEN. This paper outlines the general factors considered in an air conditioning problem. The present type of applications in the ceramic industry include (1) complete drying of ware, (2) conditioning of material and formed pieces, (3) humidifying and dehumidifying of manufacturing departments, (4) air washing, (5) cooling for comfort. Illustrations showing details of some of these cases are included. The present progress indicates the general line of future development of air conditioning in the manufacture of ceramic products.

Impact properties of china.* EDWARD SCHRAMM AND F. P. HALL. A discussion is presented of the relation of impact tests on tableware to impact properties as determined on small test pieces, breaking with transverse, shearing, and compression blows. Data are given for compression impact covering the field of china bodies. The relation of impact resistance to the elastic properties of bodies is discussed.

Comparison of effects due to method of forming a body as contrasted with influence of choice of feldspar.* C. W. PARMELEE AND C. R. AMBERG. Electrical porcelain body mixture was prepared in several batches, each of which contained a different feldspar. These several bodies were formed by hand pressing, extrusion, and casting. After they

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had been burned a comparison was made of the volume changes and bulk specific gravities.

Feldspars and their peculiarities as ceramic solvents.* A. S. WATTS. Presentation of evidence to combat the fallacy that chemical composition of a feldspar is a definite indication of its behavior as a vitrifying agent in ceramic bodies. General presentation of data on the pure feldspar types and their constitution and mode of occurrence in commercial deposits. The effect of solid solution vs. associated or mixed feldspars on the physical properties of feldspars of similar chemical compositions. Consideration of the character of associated quartz and muscovite (white mica). A proposed basis of classification depending of the fusion behavior of the feldspar in the presence of quartz, kaolin, and ball clay.

Solubility of feldspar in water.* C. W. PARMELEE AND A. J. MONACK. The solubilities were determined by measuring the increase in p_H value that results from solution of the feldspar. The maximum time used was 48 hours. Twenty gram samples of feldspar were immersed in 200 cc. of water in volumetric flasks. The p_H values were determined colorimetrically at certain intervals of time. The conclusions are (1) There exists no definite relation between the ratio K_2O/Na_2O and the solubilities of feldspars in water. (2) Certain peculiarities of the feldspars are carried throughout the work. (3) Both high soda feldspar and high potash feldspar have almost equal solubilities in this work. The relations between "p_H increase" and time are shown by graphs and represented by equations.

Cost of feldspar.* CHARLES R. AMBERG. Of late years the study of feldspar has been carried on with great intensity. The Feldspar Grinders Institute has proposed various classifications of feldspars which will assist the user in buying material suitable for his use. A discussion of the use and value of these classifications is taken up in this paper and another classification based on the pounds of fluxing oxides per ton is proposed.

Commercial feldspars produced in United States and Canada.* F. P. KNIGHT, JR. This paper attempts to give consumers an impartial survey of various commercial feldspars available for their use. It presents discussions and analyses of many of the commercial feldspars mined in N. C., Me., N. H., Conn., N. Y., Pa., Md., Va., S. D., Minn., Colo., Ariz., Calif., and Canada. Analyses are given of actual shipments of ground feldspar. Discussion concerns similarities and differences between feldspars of the different sections. Quality and fineness of grinding are discussed in connection with the branches of the ceramic industry consuming feldspar. The application of the "commercial standard for feldspar" is considered.

Automatic pressing of small porcelain parts which are produced in quantity.* L. I. SHAW. A commercial reciprocating type press of approximately one and one-half tons capacity has been adapted to the automatic dry pressing of small parts. In order to insure proper formation of relatively thin-walled parts, the grain size and moisture content of the body mix is controlled within certain limits. Use is made of multiple dies with consequent increased production. Automatic filling of the dies, pressing, ejecting, and cleaning and oiling of the dies for the next cycle have been accomplished. The output per press is fifty-six parts per minute.

Simplified practice in mixing colored glazes.* V. J. ROEHM. A simple method of mixing colored glazes is discussed, using one base glaze, by means of curves plotted from predetermined values for the percentage of solids and ounces per pint in both base glaze and colored stains.

Effect of furnace atmospheres on qualities of certain types of glazes.* A. P. WATTS.

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A research sponsored by the American Gas Association was begun at Rutgers University in January, 1929. One phase of this research is the determination of the effect of furnace atmospheres. By maintaining carefully controlled conditions all variables were eliminated except that of atmosphere. Tests were made in many atmospheres using several different glazes. These atmospheres were formed either of the individual products of combustion or of combinations of gases which simulated actual furnace conditions. Three major conclusions have been drawn as follows: (1) reducing conditions cause discoloration, (2) neutral atmospheres are often harmful, and (3) sulphur dioxide is harmful when present in small amounts.

Advantages and use of CO_2 meter on forced downdraft periodic kiln as to temperature distribution.* D. M. McCann. Notes on forced downdraft system used on dry-pressed electrical porcelain fired to cone 12, showing type and general construction of the kiln, heat distribution, fuel used per firing and use of the CO_2 meter for adjusting the draft for various atmospheric conditions to get uniformly fired kilns, both as to time of firing and appearance of ware.

Cost finding in ceramic plants.* H. T. Williams. Practical problems involved in cost finding in ceramic plants were discussed.

Pebble mill linings.* Robert Twells. A comparison is made of the relative cost, life, and properties of the various types of pebble mill linings.

Casting slip control.* W. L. Sample. A claim of the inadequacy of the flow type viscosimeter for determining the properties of casting slips is made. A discussion is presented of the results obtained in a plant whose water supply is taken from a nearby river, showing the water supply to be the cause of much trouble. A remedy for soft castings is suggested in the proper proportioning and the simple test cup method of testing a batch of slip is recommended as the best method.

Production of fireclay ware. Jacoby. *Tonind.-Ztg.*, **53** [92], 1615–17 (1929).—This method of producing fire clay for sanitary ware comes from England and has been improved recently by substituting the casting process for hand labor. Three different mass compositions are necessary: the body mass, the ground-coating mass (engobe), and the glaze, the difficulty being to secure a durable adhesion of the coatings. As the fireclay ware are fired at cones 8 to 10, the refractory clay must be of a high quality, obtained by mixing different kinds of clays or by adding as much as 50% grog. An account of the preparation is given. Hardening generally depends on the water content and takes from 5 to 48 hrs. The ground coating is composed of 25 parts of feldspar, 37 kaolin, 15 quartz, 12 chalk, 5 zinc oxide, and 6 tin oxide; its preparation is outlined; gelatin or glue is used to stick this coating to the pieces. The glaze is composed of 37 parts of feldspar, 10 kaolin, 26 quartz, 13 chalk, 10 zinc oxide, and 4 tin oxide; it is ground as fine as possible and prepared in the same way as the ground coating. The ware must be quite dry before being covered with the glaze; it is then fired at cones 8 to 10, the time of firing being about 90 to 110 hrs. In the production of fireclay ware the necessity of suitably constructed molds is emphasized. M.V.K.

Darkening of tile. Anon. *Tonind.-Ztg.*, **53** [93], 1635–36 (1929).—Tile turns black because of the sulphuric-acid compounds and other impurities such as iron, manganese, and vanadium in different forms which the clay itself may contain. The changing of color due to the sulphuric acid may be prevented by the addition of barium carbonates to the clay and storing for 3 or 4 weeks. The addition of alkalis is not recommended. The cheapest and best method is to raise the firing temperature of the clay mass as high as possible as it prevents unfavorable reactions in the formation of silicates and their subsequent crystallizing out. If necessary, refractory clays

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could be added which would require a higher firing temperature, or, instead, a sintered clay, which would permit a more thorough firing. In either case the pieces would acquire a greater density which hinders the changing of color. M.V.K.

Difficulties encountered in manufacture of Dutch tile. EUGEN KILLIAS AND HANS KILLIAS. *Keramos*, **8** [23], 273–84 (1929).—The following subjects are discussed: (1) the formation of glaze on the Dutch tile, (2) action of sulphur and water vapor on the glaze during its formation, (3) fritted glazes, (4) scum formation on glazes, (5) shivering of glazes, (6) defects introduced in the application of glazes, (7) bubble formation in glazes, (8) variations in the color of colored glazes, (9) running of glazes on the ware, and (10) factors causing the crazing of glazed ware. See also *Ceram. Abs.*, **8** [12], 900 (1929). F.P.H.

German porcelain industry. A. DOUGLAS COOK. *Commerce Repts.*, **51**, 732–33 (1929).—The German porcelain industry, which manufactures household, decorative, and electro-porcelain, is composed of more than 300 factories employing approximately 60,000 workers. The household and decorative porcelain group is made up of 292 firms, and the electro-porcelain group consists of 22 firms manufacturing high-tension porcelain and 60 factories producing low-tension electro-porcelain. The manufacture of electrotechnical porcelain, however, is confined chiefly to Berlin, although small electrotechnical factories are found in the Rhineland and in Westphalia. The hand painting of porcelain is centered in the Dresden district. The raw materials employed in porcelain manufacture, *i.e.*, china clay, feldspar, and quartz, are partially obtained from foreign countries, the clay largely from Czechoslovakia and feldspar from Scandinavia. Various data on the exports and imports of the industry are presented. E.J.V.

PATENTS

Pole-top pin for multiple construction. ARTHUR O. AUSTIN. U. S. 1,740,641, Dec. 24, 1929. (1) A pole-top bracket comprising a plate, means for securing the plate to the side of a pole adjacent the top thereof, upper and lower arms on the plate projecting outwardly therefrom, a pin extending through an opening in the upper one of the arms, a bolt projecting rigidly from the pole and extending through an opening in the pin adjacent the lower one of the arms, the lower arm serving to space the pin away from the pole and an insulator carried by the pin above the pole. (2) Means for supporting a pair of insulators at the top of a pole comprising pins arranged at opposite sides of the pole, a bolt passing through the pins and through the pole, means for spacing the pins away from the pole and arms extending outwardly from the pole above the bolt, the arms have openings therethrough through which the pins extend and insulators mounted on the pins above the top of the pole.

Insulator. ARTHUR O. AUSTIN. U. S. 1,740,642, Dec. 24, 1929. A bus bar support comprising a base, an insulator mounted on the base, a metallic fitting fixed to the insulator, the fitting having an externally threaded portion, an internally threaded split ring engaging the threaded portion of the fitting, means for clamping the portions of the split ring tightly upon the threaded portion of the fitting to hold the ring in fixed position on the fitting, and means carred by the split ring for clamping a bus bar thereto.

Uniting by sealing the insulating parts of high-tension insulators. FERDINAND WECKERLE. U. S. 1,742,625 Jan. 7, 1930. The process of sealing together two like parts of material, which consists in adding cement to unvulcanized rubber in a finely-divided state, inserting the mixture between the parts, and vulcanizing the mixture after the setting of the cement.

High-tension insulator. SVEND BARFOED. U. S. 1,742,628, Jan. 7, 1930. An insulator of the character described having a body portion, and a plurality of annular interspaced superposed flanges formed on the exterior surface thereof, the spacing be-

tween the flanges being such that the air gap resistance between the flanges shall be substantially equal to the leakage path between the flanges when their surfaces are covered with dust and moisture.

Pin-type insulator. RICHARD M. KERSCHNER. U. S. 1,743,552, Jan. 14, 1930. (1) In combination with an insulator having a helically-grooved pin-receiving opening, of an insulator-supporting pin provided with threads for engaging the centers only of the grooves with a supporting force. (2) An insulator device comprising an insulator having a helically-grooved pin-receiving opening, an insulator pin having a sheet metal thimble disposed thereon, the surface of the thimble being threaded, the threads having a greater depth than the groove in the opening for engaging the center of the groove with a gripping force. (3) An insulator device including an insulator having a helically-grooved pin-receiving opening, an insulator-supporting pin provided with malleable threads of greater diameter than the diameter of the groove and of greater depth than the depth of the groove.

Equipment and Apparatus

Conversion of batch into continuous processes. J. V. N. DORR. *Ind. Eng. Chem.*, **21** [5], 465–71 (1929).—The work of the Dorr Company is described. This work deals with three principal unit operations: (1) separation of a portion of the solids from the remainder and bulk of the liquid, *i.e.*, gravity classification or selective settling; (2) separation of all the solids from largest portion of the liquid, *i.e.*, sedimentation and filtration, (3) mixing or keeping in suspension all of the solids in a mixture of solids and liquid, *i.e.*, agitation. Some of the advantages of this work are (*a*) it tends to make all processes continuous and sometimes self-regulating, (*b*) with few exceptions the equipment moves slowly so that the actual power consumed is small, (*c*) when conducting any unit operation on a fine solid-liquid mixture it is profitable to conduct it where possible with mechanical means, thus giving a positive action which avoids the delicate adjustments and the necessity of close attention to meet each change in conditions. Fine pigments, such as whiting, sienna, baryte, red iron oxide, and clay are generally prepared by water-floated methods. The usual method is to flume the water-pigment mixture through long troughs, the velocity being such that the undesirable coarse particles settle out. Periodically the troughs are taken out of service to permit laborers to shovel out the accumulated waste material, which contains a large amount of valuable fine material entrained with it. One N. C. clay producer replaced 700 feet of manually cleaned flume with a single bowl classifier and has laid off three men per shift, gets a better price for his clay, and recovers 10 to 15% more clay from the same tonnage of run-of-mine. R.G.M.

Crushing and pulverization. L. T. WORK. *Ind. Eng. Chem.*, **21** [5], 498–502 (1929).—Recent studies in the fundamental principles of crushing have followed three lines: (1) measurement or calculation of surface and its comparison with energy; (2) fineness characteristics of the product as determined by its inherent nature and by processes of crushing, and (3) behavior of materials under the force of crushing. These studies have shown (*a*) that the overall energy of crushing quartz is proportional to the dissolution rate and probably the new surface developed and that the energy theoretically necessary to develop new surface is but a small proportion of that actually used; (*b*) with the more exact methods of measurement of fineness, mathematical analysis of fineness curves has become possible. The statistical relations so far developed are available for calculations of surface and other functions. They suggest less complex relations than have been applied to milling; (*c*) the fundamental resistance to pulverization of any material and the resistance under operating conditions are important

and unmeasured properties which must be quantitatively evaluated; (*d*) a rough classification has placed the mills of interest in the chemical and related industries as (1) direct pressure mills, (2) roller mills, (3) tube mills, (4) beater mills, and (5) revolving plate mills; (*e*) new developments in crushing and pulverizing are novel designs of mills, more wear-resistant materials, simplification for repairs, new applications for closed circuit grinding, air-sweeping of mills, and automatic controls. R.G.M.

Present trends in dust recovery. E. P. PARTRIDGE. *Ind. Eng. Chem.*, **21** [5], 446–51(1929).—The various types of apparatus for the removal of dust from gas streams may be conveniently classified on the basis of what can be done with the dust after it is collected. (1) *Systems for dust collection without recovery.* Two general types exist. The first depends upon a water spray through which dust-laden air is passed with removal of those particles that are wetted by the spray. The second type, loosely styled a "filter," depends upon passing the air to be cleaned through small, tortuous channels, the surfaces of which are covered with some sticky medium which holds all particles impinging upon it. (2) *Systems for dust collection with recovery.* All types of equipment for dust collection other than the two mentioned above allow the ready recovery of the fine material separated out. Where recovery becomes an important factor in the choice of equipment the following types find application: (*a*) sedimentation by gravity, (*b*) separation by centrifugal force, (*c*) electrical precipitation, and (*d*) filtration. Sedimentation by gravity is the oldest and simplest principle used for the recovery of dust. A settling chamber is used and fair separation of large particles can be obtained under carefully controlled conditions of rate of flow, turbulence, and temperature of the gas stream. This method is now practically obsolete and its inadequacy is evident when it is realized that a spherical particle of unit density and a diameter of 1×10^{-2} cm. settles at a rate of only 30 cm. per sec. in absolutely still air. Such a particle represents merely the largest range of industrial dusts. Centrifugal force is utilized for dust collection in the cyclone separator, which exists in many varieties, all of which have the common characteristic of passing a dust-laden stream of gas in a spiral path at a velocity sufficient to cause the suspended particles to be thrown out against the containing wall, down which they drop into a container at the bottom. Velocities as high as 1500 ft. per sec. are claimed for some special cyclones of small diameter. Cyclones operate most efficiently upon gases containing particles of uniform large size, but it is possible to use two of them in series for the simultaneous removal and partial sizing of dust having a considerable range of particle diameter. Electrical precipitation removes the suspended particles, either solid or liquid, from a gas stream by producing an electrical charge upon the particles and then utilizing the pull of a powerful electrical field to cause them to travel to an oppositely charged surface to which they adhere. By the use of a special transformer and mechanical rectifier, a unidirectional corona discharge is obtained at a potential of from 50,000 to 75,000 volts. The efficiency of removal of suspended particles is a function of the length of exposure of the gas stream to the electrical field within the precipitator, but is practically independent, within ordinary limits of the concentration of the suspended material. The efficiency guaranteed for ordinary installations is 90%, although units may be built to give practically complete recovery if desired. The power consumption varies from 5 to 10 kw.-hrs. per million cu. ft. of gas treated. The electrical precipitation equipment, known as the Cottrell apparatus has two fields of operation in which it is unrivaled; first, it may be designed for operations up to 1200°F, and it may be made from corrosion-resistant materials from use in treating acid gases. Filtration of gas streams for the removal of dust is accomplished by using a pressure or a vacuum system. Practically all of the industrial filters are of the vacuum type since the pressure system necessitates passing the dust-laden air through the pressure fan. The abrasive action of the dust in many

cases causes the life of the fan to be uneconomically brief. The vacuum type of filter is built in two styles: (1) adapted from the filter press used for the filtration of liquids; (2) the stocking type, used more extensively than (1). Since none of the air filters can be operated continuously it is necessary to have two or more units in parallel so that one unit may be cut out for cleaning and still secure continuous operation. P. includes diagrammatic sketches of installations and gives a list of comparative costs for several installations handling different kinds of dust. R.G.M.

Instruments in modern power plant. H. M. HAMMOND. *Eng. and Finance*, **21** [4], 193–97 (1929).—H. discusses the use of indicating, recording, and integrating instruments in the modern steam-generating plants. R.G.M.

Crushing plant with measured and controlled screen and crusher feeds. ANON. *Rock Prod.*, **32** [25], 61–67 (1929).—An illustrated description of the coarse and fine screening plants of the Herzog Lime and Stone Co., Forest, Ohio. The fine stone is dried by open-gas flames while screening. W.W.M.

Vapor-bath process for degreasing glass. ANON. *Glass Ind.*, **11** [1], 18 (1930).—A new vapor-bath process for the degreasing of metals, glass, and other impervious materials, has been developed by the Carrier Engineering Corp., Newark, N. J., and will shortly be made commercially available. In this process a solvent known as Cecolene is boiled and vaporized. In the standard tank form of the apparatus the vapor rises to the level of water-cooled condenser coils around the sides near the top of the tank, is condensed, and precipitated to the bottom of the tank. Since the vapor is more than three times as dense as the air there is no tendency to overflow or escape. The objects to be degreased are suspended in the vapor which condenses on their cold surfaces at once and runs off profusely, carrying with it all grease. The objects are kept in the vapor until they heat up to its temperature, in $1^1/_2$ to 3 min., the time depending upon the gage or weight of the metal or other material. They are then removed in a warm, perfectly dry and clean state, any foreign matter remaining being in the form of easily removable dust. The objects being degreased do not come into contact with grease previously removed from other material, since the solvent vaporizes at a temperature much lower than the grease, which remains in the liquid below. Economy results from the fact that the chlorinated solvent can be used over and over, the vapor never becoming "dirty." Cecolene is a blanket term for a group of chlorinated solvents adaptable to various uses and materials, and the Carrier research department is prepared to supply any needed variation of the formula for a special case. E.J.V.

Newly developed instruments. ANON. *Brick Clay Rec.*, **75** [13], 832 (1929).—The Brown Instrument Co., Philadelphia, has brought out a new line of instruments. The line of remote type instruments includes those for indicating, recording, or controlling at long distances, pressures, flows, liquid levels, or special data involving the position or motion of a member or element requiring observation or control at a distance. E.J.V.

Evaporation. P. DEWOLF. *Ind. Eng. Chem.*, **21** [5], 451–56 (1929).—D. presents descriptions and diagrams of various types of evaporating equipment used in the chemical industries. R.G.M.

Calcination. W. S. DICKIE. *Ind. Eng. Chem.*, **21** [5], 461–64 (1929).—D. describes various types of calcining furnaces and discusses their application in various industries. The cement industry does much more calcining than any other one industry and probably led in development and experimentation. Aluminum and bauxite ores are calcined, although in most cases the process is more of the nature of dehydration at high temperatures. It is probable that most of the gypsum used today is calcined in rotary kilns and that future installations will be rotary kilns rather than calcining kettles. The rotary kiln is used in the dehydration of fullers' earth and also in the revivifying of the earth after it has been used. R.G.M.

Mechanical handling of materials in and about the chemical plant. I. A. K. BURDITT AND W. F. SCHAPHORST. *Ind. Eng. Chem.*, **21** [5], 489–93 (1929).—The material handling equipment available for use in chemical plants and the synchronization of production with material handling are discussed. The advantages and adaptability of the various types of conveyers for different uses are compared. R.G.M.

Works control and laboratory equipment. A. SCHRODER. *Ind. Eng. Chem.*, **21** [5], 481–85(1929).—S. describes the trend toward better instruments and their increasing use in industry. Some of the most recent developments in control instruments are colorimeters, now used extensively in the paint, enamel, and glass industries; humidity controllers; heat indicators and controllers, which include pyrometers, or the thermocouples, vapor pressure and optical type, and thermometers; liquid and gas meters; gas analyzers; acidity and alkalinity meters; viscometers; and scales and balances of new design. Laboratory glassware and porcelain have been greatly improved in quality and reduced in price during the past ten years. R.G.M.

Metallic materials of construction for chemical engineering equipment. E. P. PARTRIDGE. *Ind. Eng. Chem.*, **21** [5], 471–76(1929).—P. discusses the metals and alloys available at the present time and mentions the factors which should be considered in choosing a material for a specific piece of equipment. These factors are (1) permanence of process, (2) mechanical properties and fabrication possibilities, (3) corrosion from the standpoint of service life of material, and (5) replacement facilities. A table listing selected data on metals and alloys is included. R.G.M.

Automatic control in chemical industries. J. GINSBERG. *Ind. Eng. Chem.*, **21** [5], 410–14(1929).—G. discusses the types of automatic temperature and pressure controllers now manufactured, their mechanism, and application. R.G.M.

Mechanical dispersion by means of colloid mill. P. M. TRAVIS. *Ind. Eng. Chem.*, **21** [5], 421–25(1929).—Colloid mills may be classified in three main groups with regard to the mechanism utilized for producing dispersion: (1) beater type, (2) smooth-surface type, and (3) rough-surface type. T. discusses the relative merits of each type and their utilization in industry. R.G.M.

Velocity of air in drying chamber. OTTO NEGENDANK. *Tonind.-Ztg.*, **53** [86], 1524–25 (1929).—The velocity of the air is an important factor in the drying process. If an alternate air current cannot bring successful results, then an even current will likewise be ineffective if the velocity is too great. A high velocity does not produce a proportional increase in the drying action. A low velocity undoubtedly reduces the spalling and bending of dry ware and improves the solidity of stoneware, but on the other hand, it lowers the output. M.V.K.

Experimental study of loss of head in a closed pipe carrying clay slurry. CHARLES HANOCQ. *Trans. Amer. Soc. Mech. Eng.*, **51** [15], 75–78 (1929).—Taking as a basis for his calculations the formulas presented in a previous paper by an American investigator on the loss of head in a closed pipe carrying clear fluids, H. seeks to apply them to a fluid carrying a heavy proportion of solid materials. He takes the conclusions in the original paper, which he assumes at first sight to be somewhat contradictory, and shows that no anomalies exist, and further brings out some precise deductions on the loss of head in a pipe carrying muddy water. E.P.R.

Coal pulverizers. W. J. A. LONDON. *Trans. Amer. Soc. Mech. Eng.*, **51** [12], 159–66 (1929).—Commercial coal pulverizers vary greatly in their performance. While there are two principles of attrition and impact on which pulverizing mills are based, there are such radical differences of design as to raise the question of correct fundamentals. Guarantees are given on performance when the engineering problems are difficult to determine with any degree of accuracy. Analysis of what actually takes place in a mill leads to a suggested design. E.P.R.

Unit motor drives. RICHARD L. CAWOOD. *Brick Clay Rec.*, **76** [1], 40–42 (1930).—Group drives still exist in plants, but the trend is toward individual motor drive, with the motor built in as an integral part of the machine, where the motors are of small or medium size. When motors are too cumbersome to be built into the machine they rest on a separate foundation situated close to the machine that is being driven. Many advantages accrue from the use of motor drives, including (1) much greater flexibility, because any portion of the plant or any single machine can be operated without any other part of the plant being operated, (2) lower wear on both the motor and the machine, (3) greater efficiency because of no belt slippage, (4) less floor space required, and (5) higher quality of production due to less contamination by dirt and oil carried by belts and shafting. E.J.V.

Machinery for cutting brick and similar products. P. RENAULT. *Rev. mat. constr. trav. pub.*, No. 242, pp. 236–40B (1929).—Various types of machinery are described and illustrated. A.J.M.

Ceramic industry and modern methods. E. G. GUERRÉE. *Rev. mat. constr. trav. pub.*, No. 242, pp. 225–29B (1929). A.J.M.

Calculation of piping in hot air heating with natural circulation. R. GIBLIN AND A. MISSENARD. *Chaleur ind.*, **10**, 305–11 (1929). A.J.M.

Temperature regulator. BLACK. *Jour. Sci. Instruments*, December, 1928; abstracted in *Chaleur ind.*, **10**, 319 (1929). A.J.M.

General survey of materials handling conditions. JOHN CARMODY. *Trans. Amer. Soc. Mech. Eng.*, **51** [19], 31–32 (1929).—That a great many opportunities exist for further development of methods to do work more efficiently is brought out in this paper. C. finds a great disinclination on the part of managers to use, in their own industry, methods that are producing effective results in another. Best results will come from seeking new ideas and applying them to the particular needs found. Engineers should take more ideas from one industry into another. E.P.R.

Modified universal stage. III. R. C. EMMONS. *Amer. Mineralogist*, **14** [12], 441–61 (1929).—E. describes a microscope for determining principal refractive indexes by the imersion method using the universal stage. From any one grain of a biaxial of moderate birefringence, regardless of its original orientation, it is possible to measure all three refractive indexes. A new universal stage is described which permits the operator, after orienting a mineral in such a way that X, Y, or Z is parallel to the axis of the microscope, to rotate the crystal on either of two mutually perpendicular horizontal axes. The last step is possible only on the modified stage. Also a water cell is described which makes possible the variable temperature control of the mount. The "double variation" procedure with the universal stage is outlined. If X (or Y or Z) is parallel to the axis of the microscope and the two critical indexes are determined it may not be possible to rotate a full 90° to obtain the third index. A procedure is given whereby the index is read at a chosen rotation and a graph gives the correct extrapolation for the 90° position. The attempt is made to avoid all graphical construction on the part of the operator and to present a procedure which is only a modification of the standard immersion methods so widely used in America. For previous abstract see *Ceram. Abs.*, **9** [2], 134 (1930). F.P.H.

Milling methods in 1929. GALEN H. CLEVENGER. *Mining and Met.*, **11** [277], 41–42 (1930).—For primary milling, there is still the choice between fine crushing rolls and rod and ball mills. It appears that in many cases the economic differences between them are not great and in some cases they are so small that the relative cost of roll shells or rods may swing the balance one way or the other. The ball mill has firmly established itself as the one machine for secondary or fine grinding. There has been nothing new in classifiers, but there has been a better understanding of the proper use

of existent types and more than ever an appreciation of the influence of proper classification or grinding efficiency. The work of Gross and Zimmerley has thrown new light upon the whole problem of fine grinding and classification. See also *Ceram. Abs.*, **8** [3], 209 (1929). F.P.H.

New vibrating screen. ANON. *Mining and Met.*, **11** [277], 69–70 (1930).—A late development in so-called "high-frequency" vibrating screens is the jigger. The jigger is of the positive eccentric-throw type. The screen body is mounted on rubber disks which are in turn secured to a tiltable framework. The framework pivots about a shaft which runs beneath the frame and which carries the eccentrics and two heavy flywheels. These latter confine the vibration to the screen itself, while the eccentrics cause the vibration. From time to time, in order to meet the conditions imposed by a particular screening problem, it is necessary to find the most effective combination of angle, amplitude of throw, speed of vibration and direction of rotation. With the jigger the angle may be changed, as noted, to +50° from the horizontal even while the screen is in motion. The eccentricity is variable at will, from $^3/_{16}$ to 0 in., and it is accomplished by rotating the eccentric upon the drive shaft, which is itself eccentric. Speed and direction of rotation are easily changed, since most screens of this type are driven by individual motors. F.P.H.

Synchronous motors prove advantageous for driving cone crushers. W. C. KING. *Eng. Mining Jour.*, **128** [19], 742 (1929).—A good comparison of the relative merits of synchronous and induction motors. E.C.C.

Importance of classification in fine grinding. J. V. N. DORR AND A. D. MARIOTT. *Eng. Mining Jour.*, **128** [23], 880–88 (1929).—Flow sheets of grinding operations, operating data, and cost sheets for grinding and classifying ores at nine North American mining operations are given. E.C.C.

Operation and efficiency of air separation. P. ROSIN AND E. RAMMLER. *Zement*, **19** [26], 31–32 (1929); *Rock Prod.*, **32** [23], 95 (1929).—Air separators and the principles of air separation as applied to the preparation of pulverized coal are discussed. W.W.M.

Russian trade. ANON. *Abrasive Ind.*, **11** [1], 43 (1930).—A catalog of American industry and trade has been issued by the Amtorg Trading Corp., containing 1000 pages, 150 pages of alphabetical list of American machinery, and equipment with the names of 6500 principal companies manufacturing the equipment. E.P.R.

Developments in crushing and grinding machinery. CARL NASKE. *Z. Ver. deut. Ing.*, **73** [50], 1781–87 (1929).—A review of the developments of the past ten years in the construction of machines for preliminary crushing, grinding, and sieving of cement, raw materials, clinker, coal, and other related substances. Illustrated by diagrams of some of the machines. L.T.B.

Pallets of pressed metal. ANON. *Brit. Clayworker*, **38** [452], 325–26 (1929).—The increasing popularity of driers of the corridor or Keller type has drawn attention to the disadvantages of wooden pallets, and has led to the invention of various other types. The objections of pressed steel pallets in the past have been (1) rust, (2) excessive weight, and (3) liability to dent or bend. These objections have been largely overcome at present by using either rustless iron or galvanized iron, and the pallets have large holes or perforations to avoid excessive weight. Such pallets are good conductors of heat and, therefore, enable brick to dry more quickly than when boards are used. Under similar conditions of drying with wood vs. iron pallets about $^1/_6$ less fuel is used with the latter. R.A.H.

Manufactured weather. D. C. LINDSAY. *Ind. Eng. Chem.*, **21** [5], 502–505 (1929).—L. describes humidity- and temperature-control apparatus and its application in industry. R.G.M.

Trend of filtration. A. WRIGHT. *Ind. Eng. Chem.*, **21** [5], 493–95 (1929).—W. discusses the history of filters and recent improvements of design. The success of present-day continuous filtration depends on the complete discharge of the filter cake from the filter cloth. The length of time for dewatering should be carefully determined on an economic basis. A product may be dewatered 0.5% more by lengthening the time of dewatering 50%, but when this requires more machines, more power, and increased filter cloth and renewal expenses it is a loss. The present trend is to introduce automatic filters for their ability not only to save labor, filter cloth costs, and other such tangible savings, but to insure continuity and uniformity of product independent of the personal efficiency of the operator. Filtration is an intermediary unit process, the functioning of the filter depending upon the condition of the product fed to it, and its end products should be in a condition best for the subsequent process. The objective of the filter must be definite so that the design may be adequate, the construction correct, and the operation economical and efficient. R.G.M.

Design standard gages. ANON. *Abrasive Ind.*, **11** [1], 43 (1930).—The Brown & Sharpe Mfg. Co. (Providence, R. I.), has developed gages conforming in design to the standards specified by the American Gage Design Committee. These gages are reliable and are of a most convenient and practical design. E.P.R.

BOOK

Theoretical and Practical Study of Transportation and Mechanical Handling of Materials in Factories, etc. Vol. II. GEORGE VON HAUFFSTENGEL. (In French). 385 pp., 555 figs. Published by Béranger, Paris. Reviewed in *Chaleur ind.*, **10**, 321 (1929). A.J.M.

PATENT

Clay-treating attachment for pug mills. JOHN GRETENCORT. U. S. 1,740,504, Dec. 24, 1929. Feeding and agitating apparatus comprising open-receiving means into which a comminuted substance is discharged, means to inject a stream of liquid into the substance at one end of the receiving means, a shield to prevent splashing over of the liquid and substance to set up a swirling action, a spreading device at the opposite end of the receiving means including a plurality of variously directed wings interrupting the swirling action and forming a plurality of channels through which the liquid and substance are discharged and means for discharging a liquid into the trough adjacent to the spreading device.

Kilns, Furnaces, Fuels, and Combustion

Washing and preparation of coal. H. D. SMITH. *Trans. Amer. Soc. Mech. Eng.*, **50** [33], 25–31 (1928).—The washing and preparation of coal covers a wide scope, and S. briefly describes the processes in common use and gives some idea of costs from the coal operator's standpoint. E.P.R.

Constitution and classification of coal. A. C. FIELDNER. *Trans. Amer. Soc. Mech. Eng.*, **50** [33], 1–9 (1928); for abstract see *Ceram. Abs.*, **8** [5], 354 (1929). E.P.R.

K.S.G. process of low-temperature carbonization. WALTER RUNGE. *Trans. Amer. Soc. Mech. Eng.*, **50** [15], 17–27 (1928).—R. deals first with the development of the K.S.G. low-temperature process of coal carbonization, the principle of operation, and the field of application of the process. The constructional details of the retorts are described, as are also the method of heating, fuel handling, gas and tar recovery, and the types of coals suitable for the process. The yields of products per ton of coal of

a given analysis are tabulated, and expected yields based on typical American coals are estimated. E.P.R.

Unit system of coal pulverizers for generation of steam. JOHN BLIZARD. *Trans. Amer. Soc. Mech. Eng.*, **50** [33], 97–101 (1928).—The unit system for pulverizing coal is taken to mean a system wherein raw coal is fed directly to a pulverizer in which it is pulverized, mixed with air, and then blown by a fan directly to the burners. The fan used to blow the mixture of coal and air usually is integral with the pulverizer, although with some systems the fan is driven by a separate motor. The principal feature of this system of pulverizing coal is its simplicity. E.P.R.

Low-temperature carbonization of southern Appalachian coal. LEO HOLDREDGE. *Trans. Amer. Soc. Mech. Eng.*, **51** [22], 333–37 (1929).—After discussing the principal reasons for the low-temperature carbonization of bituminous coal, H. describes briefly the four types of methods used or proposed for low-temperature carbonization, and then gives details regarding a laboratory experiment carried out at the Univ. of Tenn., Eng. Expt. Sta., the primary purpose of which was to produce a smokeless fuel in a form suitable for domestic use. A summary of the results of ten tests of a high-volatile northern Tenn. steam coal is included which gives quantities of semicoke, gas, tar, and tar products produced, together with their gravities, heating values, etc. The coke obtained is easily ignited, burns smokelessly even in an open grate, and, H. believes, should find a market as a domestic fuel. E.P.R.

Rapid fire tunnel kiln designed for small production.* A. L. DONNENWIRTH. A miniature tunnel kiln designed by the A C Spark Plug Co. to fire spark plug porcelain to cone 17 is used in their foreign plants. It is capable of producing about 10,000 porcelains daily. The total firing time is only slightly more than two hours.

Use of fuels in tunnel kilns. W. E. RICE. *Trans. Amer. Soc. Mech. Eng.*, **50** [33], 43–50 (1928); for abstract see *Ceram. Abs.*, **8** [10], 762 (1929). E.P.R.

Methodical heating. A. BOUCHET. *Chaleur ind.*, **10,** 269–76 (1929).—B. discusses the following points: (1) distribution of heat in a continuous kiln, (2) refractory products in a Hoffman kiln, (3) conditions of operation, (4) influence of the temperature of the gases, and (5) preheating air for combustion by passing it over the fired products. Examples of the necessary calculations are given. A curve shows the heat required to raise 1 kg. of material from 0 to 1000°C. A.J.M.

Fuels and their use in ceramic kilns. F. NIEBLUNG. *Tonind.-Ztg.*, **53** [91], 1605–1607 (1929).—N. enumerates and gives a description with different tables of all the kinds of fuels used in ceramic production in Germany. He describes their chemical composition, their heat units, and points out their advantages and defects. M.V.K.

Automatic combustion control. PEEBLES. *Jour. Inst. Fuel*, January, 1929; abstracted in *Chaleur ind.*, **10,** 319 (1929). A.J.M.

New burner for liquid combustible. JEAN SAUVAGEOT. *Chaleur ind.*, **10,** 260 (1929).—Only 2 to 3% of the air necessary for combustion is used for atomizing the fuel. The remainder is drawn in by the stream of atomized fuel and is mixed with it. A.J.M.

Test code for liquid fuels. ANON. *Mech. Eng.*, **51** [12], 958–60 (1929).—Tentative draft of a code in the series of 21 formulated by the A.S.M.E. committee on power-test codes is given. E.A.H.

Fuels in brick kilns. W. E. RICE. *Trans. Amer. Soc. Mech. Eng.*, **50** [8], 81–95 (1928).—This article is to familiarize fuel engineers with the peculiar requirements of brick-kiln operation. It briefly describes the firing process and the limitations this imposes upon the fuel or combustion engineer, illustrates some of the faults that are

*Paper presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Toronto, Ont., February, 1930. When this paper is published reference will be given.

often found and the corrections that may be applied, and points to some possible improvements. E.P.R.

American fuel resources. O. P. HOOD. *Trans. Amer. Soc. Mech. Eng.*, **50** [8], 5–8 (1928).—The fuel resources of America can be referred to in a general way as superabundant. While gaseous and liquid fuels are in relative abundance, the main supply of energy comes from solid fuel. Of lignitic coals there are nearly a thousand billion tons. The dependence of our great industries is on bituminous coal, found in twenty-eight states. The fourteen hundred billion ton reserves include thinner seams and deeper-lying and more distant beds than are now commercially of use. Reserves at present economic level are a very much smaller quantity. The rapid increase in fuel used per capita is likely to continue for some time. The fact that more than one-half of the world's coal reserves are believed to lie within the territory of the U. S. has led to too much unwarranted optimism. E.P.R.

Progress in fuel utilization in 1928. EXECUTIVE COMM., FUELS DIV. *Trans. Amer. Soc. Mech. Eng.*, **51** [12], 79–84 (1929).—In almost all phases of fuel utilization the past year has been characterized by consistent development of methods previously introduced and of equipment, the use of which has already been initiated. The greatest advances have been made in those branches of fuel utilization in which the largest quantities of fuels are employed. The predominant tendency, however, to increase the effectiveness of fuel-utilization processes has caused an increasing amount of attention to be paid to combustion processes in those industries which have hitherto not shown active progress. The report is intended to summarize the more important advances which have been made during 1928. E.P.R.

Low-temperature distillation of low-grade fuel, especially lignites. MAX TOLTZ *Trans. Amer. Soc. Mech. Eng.*, **51** [12], 209–11 (1929).—The advantages of apparatus which is used in low-temperature distillation of low-grade fuels are presented. Lignites found in the northwestern portion of the U. S. are given special reference. E.P.R.

Waste-heat recovery. W. GREGSON. *Glass*, **6** [9], 138–41 (1929).—Waste heat is defined as the sensible heat in the gases discharged from any industrial furnace or prime mover after the primary functions of the furnace or engine have been fulfilled. In the case of furnaces, it is obvious that gases must leave the furnace itself at a temperature higher than the process temperature, hence the correct nomenclature for the heat in the exit gases should really be "surplus heat." "Waste heat" is now the universally accepted one, although it gives an erroneous definition of the subject concerned. There are two distinct processes by which waste heat can be recovered (1) by direct recovery and return to the furnace, *i.e.*, by regeneration or recuperation, whereby the ingoing air of combustion is preheated by the sensible heat in the outgoing products, and (2) by steam raising. Recuperators and regenerators are discussed as to their advantages and disadvantages. Waste-heat boilers are also discussed and typical test figures on fire-tube waste-heat boilers are given. The paper deals with metallurgical furnace installations but the principle may be applied elsewhere. O.E.M.

Measuring fuel oil in tank cars. H. L. KAUFFMAN. *Power*, **70** [24], 930 (1929).—Arguments between buyers and sellers of fuel oil can be avoided by the proper gaging of the tank car, with a correction for the temperature. The "innage" (amount of oil in the dome) or the "outage" of a tank car is measured by the distance between the edge of the tank shell, which extends well out in the dome, and the surface of the oil with a 3-foot rule; *i.e.*, "innage" is measured by lowering the rule through the liquid in the dome until it rests on the tank shell and reading the wet portion of the rule. "Outage" is measured best by using two 3-foot rules fastened together by brass guides and a thumb screw for adjustment. One rule is rested on the edge of the tank shell

and the other tapped down until it reaches the surface of the liquid, the reading made at the upper end of the rules in a convenient position. "Innage" is added to the rating of the car as stamped on the side while "outage" is subtracted. Temperature corrections are added to the observed reading if the temperature of the oil is under 60°F; if over 60°F it is subtracted. Tables giving gal. per in. in tank car domes of various sizes and temperature corrections are given in the article. Such tables may be had from the A.S.T.M. under heading, "Standard Abridged Volume Correction Tables for Petroleum Oils," Serial Designation D206–25. Tables are approved by the Bureau of Standards and Bureau of Mines. O.E.M.

Coal-washing investigations, methods and tests. H. F. YANCEY AND THOMAS FRASER. Bur. Mines, *Bull.*, No. 300, 259 pp., 48 figs. R.A.H.

Chemical constitution of coal. J. B. SHOHAN. Bur. Mines, *Rept. of Invest.*, No. 6212 (1929).—S. outlines recent accomplishments in the chemistry of coal and reports progress in the study of coal substance as a whole by microscopic means, treatment with solvents, attacks by reagents, and decomposition by heat; also by examination of distinct constituents such as plant remains, bitumens, and ulmins. Recent work of Fuchs and of Francis and Wheeler (see *Ceram. Abs.*, **8** [5], 357 (1929)) is emphasized. Bibliography. R.A.H.

Use of lime in fuel. ANON. *Rock Prod.*, **32** [23], 82 (1929); *Stone Trades Jour.*—Agitation with hydrated lime or ground quicklime, at 80°C is included in the preparation of some fuel oils. This increases their stability and removes corrosive acid compounds. Lime is sometimes mixed with the binder used in making fuel briquets. W.W.M.

Electrical heating by container-resistance method. R. A. CARLETON. *Ind. Eng. Chem.*, **21** [6], 525–29 (1929).—C. describes a new method, called the container-resistance method, of applying electrical heating which has been developed for use in a number of industries. Articles of process equipment become their own heating systems. R.G.M.

Economics of producer gas, fuel oil, and natural gas compared. II. JOHN W. ROMIG. *Glass Ind.*, **11** [1], 1–3 (1930).—In this part an analysis of producer gas as tank fuel is made. In the development of this subject a glass tank using producer gas from coal is assumed as a starting point, although the start could be made just as well if fuel oil or natural gas were the normal fuel. The quantity of fuel required per unit time must be known for the individual tank in order to make accurate comparisons. Data necessary for the calculations are: ultimate analysis of coal, average producer gas analysis, average temperature of air and gas preheat at top of checkers, and tank temperature. Carbon in the gas and tar mists may be neglected if the gas mains are properly designed and are long. If the mains are short consideration must be given tar mists and free carbon. Evaluation of coal is made on the "as received" basis of the fuel, as that is the purchase basis of the fuel. Calculations are made on a 60°F base. Using typical data for an example, the method of determining the useful heat delivered to the melting chamber of a glass tank when producer gas is used as the fuel with regenerative glass tanks is illustrated by a detailed calculation. The results are useful in comparing producer fuels of different characteristics and purchase prices as well as for securing equivalent fuel values of fuel oil and gas. For Part I see *Ceram. Abs.*, **9** [2], 122 (1930). E.J.V.

Natural gas for firing clay products. CHARLES BUTZ. *Brick Clay Rec.*, **75** [14], 883–85(1929).—A new fuel that will, in many instances, reduce the cost of production of clay ware is being brought to the ceramic industry by the rapid expansion of natural gas distribution. The Denver Fire Clay Co. was one of the first to use natural gas as a fuel in the production of refractory brick. Metering arrangements are variable according to the size of the plant and the requirements of the prevailing cost accounting

system. The matter of distribution to the kilns is also taken up, using the experience gained at the plant for citations and examples to illustrate various points. The products of this company consist of firebrick and fireclay shapes, each kiln being set for the maximum tonnage, as there is a loss in setting a kiln with anything less. The details of the equipment and firing method used on the kilns are given. To summarize the advantage of gas over other fuels it is pointed out that gas is being used successfully and economically in firing building brick, fire brick, sewer pipe, and terra cotta. With the rates made available by gas companies it is often an economy where fuel costs are compared. By using gas, the labor of firing will be reduced materially. One man can easily care for from 10 to 15 kilns and the time of firing can be reduced 15%. Kiln repairs are less, due to accuracy of flame control which permits firing a kiln with a lower firebox temperature. A smaller percentage of spoiled ware is secured because of the better control of temperature and flame and because of the larger volume of less intense flame. Equipment should be selected so that (1) the burners can burn with less gas per M brick or per ton of ware; (2) should be so constructed and installed that it can be readily and easily operated for the control of gas flow, length of flame, and kiln atmosphere; (3) should withstand, without deterioration, the severe service to which it is subjected; and (4) should be economical in cost and operation.

E.J.V.

Dry quencher operation at Rochester, N. Y. F. J. Pfluke. *Ind. Eng. Chem.*, **21** [5], 457–61 (1929).—P. describes the dry-coke quencher installation and compares the method with the wet-quenching operation. R.G.M.

Calculation of latent heats of vaporization of hydrocarbons and alcohols. J. W. Schultz. *Ind. Eng. Chem.*, **21** [6], 557–59 (1929).—A method of calculating the latent heats of hydrocarbons and alcohols at any temperature is discussed. The method consists essentially in establishing a Düring line from the boiling points at at least two temperatures and a molal entropy line from two or three known temperatures. The method has been applied successfully to four hydrocarbons and two alcohols for temperatures nearly up to the critical. R.G.M.

Fuel utilization in ceramics. II. A. T. Green and A. J. Dale. *Pottery Gaz.*, **55** [631], 117–21 (1930).—For the hardening-on of overglaze colors on whiteware, and for the firing of terra cotta, enameled brick, and similar goods, of which the appearance would be damaged by direct contact with the heating gases; muffle kilns are almost essential for economic heat treatment. The thickness of the muffle walls and the thermal diffusivity of the refractory of which the wall is constructed, give an important bearing on the fuel consumption of a given design of muffle kiln, since these factors limit the rate at which the temperature of the goods can be raised, and also the duration of the cooling period. The updraft periodic muffle is widely used where muffle firing is essential. This follows the design of the ordinary updraft kilns. In kilns of the intermittent type, if the principle of heat regeneration is applied to kiln practice, economy in fuel consumption will result. All systems of continuous firing are similar in principle and in that they consist of a single tunnel, or of two tunnels connected at their ends. Goods in one section of the structure are being fired; all or part of the air required for combustion is preheated by passage among the cooling goods which have already been fired in another part of the kiln; the waste gases from the firing section pass through and preheat unfired goods before leaving the structure. In practice, however, the principle is applied in two totally distinct ways. The application of the system of continuous firing can be divided as follows: (1) goods stationary, (*a*) continuous tunnel with moving fires, (*b*) adjacent chambers with moving fires; (2) goods moving, the tunnel kiln with fixed firing zone. The Hoffman kiln is described in detail and the disadvantages are given as follows: (1) a certain amount of heat is lost in the kiln walls

as the fire zone advances along the structure; (2) a certain fraction of the goods is badly defaced by the slagging action of the fuel which is in direct contact with them; (3) the ordinary "grates" on which the fuel burns among the goods are inefficient, and it has been estimated that in extreme cases, as much as 6 to 10 times the theoretical quantity of air is required for combustion of the coal. The principle of the continuous chamber kiln is almost identical with that of Hoffman, air for combustion being preheated by the cooling goods in chambers behind the fire, while the products of combustion pass on to preheat ware in sections in advance of the fire. Part of the fuel economy of a continuous kiln is sacrificed sometimes for reasons specific to plant and type of product, and it is not unusual to find the continuous tunnel circuit displaced by a single row of adjacent and interconnected chambers. The simple semicontinuous kiln cannot achieve the thermal efficiency of the continuous structure since (1) when the first chamber is being fired initial heating by air drawn through cooling chambers is not possible; and (2) as the last chambers of the row are being fired there is an incomplete regeneration of the heat in the products of combustion. The best features of a tunnel kiln are (1) a long firing zone to insure adequate soaking; (2) an open-fired kiln, *i.e.*, one in which the products of combustion pass directly through the goods; (3) a type of construction which has the utmost flexibility in the matter of arranging the uniform heat distribution throughout the goods and for proper variation in the rate of heating in certain critical preliminary stages of firing; (4) a structure, which, while strong, allows the best possible use of heat which is permitted to pass through the walls and crown by conduction; (5) the avoidance of radiation from solid surfaces much hotter than the goods being fired; and (6) a correct balance between the resistance of the full tunnel to the passage of hot air (or products of combustion) and the hydrostatic pressure of the furnace gas entering the tunnel. The tunnel kiln forms an ideal unit for the use of insulation. An analysis of various reports on the oil-firing of ceramic kilns shows that it possesses certain advantages. These may be summed up as (1) excellent control, (2) short duration of firing, and (3) increased cleanliness. In the firing of whiteware, the sagger loss is considerably reduced. Thermal data on the various types of kilns are included for purposes of comparison. For Part I see *Ceram. Abs.*, **9** [2], 121 (1930). E.J.V.

Characteristics and combustion of coal. T. J. Ess. *Blast Fur. Steel Plant*, **17** [12], 1829–32 (1929).—A study of the varieties and composition of coals with special reference to their use as an industrial fuel is presented. See also *Ceram. Abs.*, **9** [2] 124 (1930). F.P.H.

Centrifugal dust removers. I. M. SEILLAN. *Chaleur ind.*, **10**, 233–38 (1929).—The problem of removing powdered ash and carbon from the products of combustion of coal is studied and the mathematical theory of mechanical removers is given. **II.** *Ibid.*, **10**, 289–93.—The mathematical discussion is continued. A.J.M.

Need of draft regulator. ANON. *Brit. Clayworker*, **38** [452], 325 (1929).—Every kiln fireman knows the disastrous effects of variations in the wind on the goods being fired but few manufacturers and still fewer firemen are aware that many of these variations can be prevented by the use of a draft regulator at or near the base of the chimney. Two figures are included in the article showing changes in draft in moderate and strong draft, respectively. Two types of draft regulators are briefly described. Tests on regulators on numerous kilns show an average saving in fuel of 22%. R.A.H.

Erosion of kiln linings. ALFRED MÜLLER. *Tonind.-Ztg.*, **53** [83], 1481–83 (1929).—In order to account for the rapid erosion of kiln linings in the presence of fluorspar, M. made tests of the linings, the deposits found on them, and the stone beneath. It was found that in the presence of fluorspar an increase in the alkali content of the lining and a decrease in the sesquioxides, Al_2O_3 and Fe_2O_3, takes place. An explanation of

how this occurs is given. M. recommends caution in use of fluorspar as an aid to sintering. M.V.K.

Cause of fine cracks in face brick. P. THOR. *Tonind.-Ztg.*, **53** [91], 1602–1603 (1929).—Opinions vary as to the cause of fine cracks in face brick. According to investigations made by T., they are caused by heating too rapidly and by an insufficient preheating time with too small an amount of smoke and too short a smoking period. T. recommends a longer preheating period with higher temperatures before they are subjected to the kiln gases. In this way abrupt changes of temperature are avoided and the heating is more gradual. M.V.K.

Protection of arches and walls of boiler furnaces by means of ashes. J. DESCHAMPS. *Chaleur ind.*, **10,** 230–32 (1929).—Tubes hold the ashes in place and thus protect the refractories. A.J.M.

Drier calculations. I. L. RAMZINE. *Chaleur ind.*, **10,** 219–29 (1929).—R. presents the following points: (1) Fundamental physical properties of humid air are dry air, water vapor, approximate formulas and properties of humid air such as per cent humidity, partial pressures, volume of mixture (air and vapor), absolute and relative humidity, quantity of heat contained in humid air, and specific heat of humid air. (2) The heat balances of driers and analyses of the calculations include (*a*) plant of drier, (*b*) weight balance for drier, (*c*) humidity balance and discharge of air, (*d*) heat balance in which a hypothetical drier without loss, a drier under actual conditions, and drier losses to surrounding atmosphere are considered. The calculations are detailed. Two diagrams show the relations between per cent humidity and the heat content of the air-vapor mixtures. **II.** *Ibid.*, **10,** 294–304.—The following material is given: the humidity-heat content diagram shows (1) construction and fundamental properties of the diagram, (2) theoretical drier, and (3) actual drier. A chart shows the relation between humidity and heat content in a quantitative manner and the construction of such a chart is given in detail. A.J.M.

Firing a continuous kiln. J. WELTER. *Rev. mat. constr. trav. pub.*, No. 242, pp. 229–33B (1929).—W. discusses the matter of placing the ware in the kiln. For previous abstract see *Ceram. Abs.*, **9** [1], 56 (1930). A.J.M.

Kiln fired to 2000°C. R. JUNG. *Stahl Eisen*, No. 34 (1929); *Tonind.-Ztg.*, **53** [96], 1700 (1929).—The material used in the construction was of zirconium-dioxide previously fired to 2000°C. The kiln is heated by kerosene which is mixed with oxygen and sprayed into the kiln as fine mist. M.V.K.

Pound-molecule as the unit in gas calculations. V. D. J. DEMOREST. *Gas Age-Rec.*, **64** [26], 934 (1929).—Just as a gram-molecule is the molecular weight in grams, so the pound-molecule is the molecular weight in pounds. The convenience in the use of the pound-molecule (or gram-molecule) comes from the fact that all gaseous molecules occupy the same volume, *i.e.*, they have the same "volume of influence" or, as expressed in Avogadro's Law, "equal volumes of all gases contain the same number of molecules." Consequently the pound-molecular weight of any gas occupies the same volume as the pound-molecular weight of any other gas. At 60°F and 30 in. of mercury pressure the pound-molecular volume of any of the permanent gases is practically 380 cu. ft. For previous abstract see *Ceram. Abs.*, **9** [2], 122 (1930). F.P.H.

Creosote in manufacture of carburetted water gas. I. F. J. DENT. *Gas Age-Rec.*, **64** [26], 935–36 (1929).—Owing to the impossibility of obtaining supplies of gas oil from America during the European War, creosote oil came into use as an enriching agent for blue water gas. The difficulties which arose during the use of creosote, such as deposition of carbon in the carburetor and excessive production of naphthalene, together with the poor yield of gas obtained from it, caused engineers to revert to petroleum gas oil when supplies of the latter became normal. The recent restriction

in the market with a consequent fall in the price of creosote has, however, made further outlets for this product desirable. Accordingly, it has been proposed to make further investigation into the possibility of using creosote or mixtures of creosote with gas oil in the manufacture of carburetted water gas. It is hoped that the lighter creosotes now obtainable from tar from steamed vertical retorts will prove to be more suitable for this purpose than the heavier creosotes of the war period. F.P.H.

Installation and operation of gas producers for metallurgical furnaces. I. J. S. ATKINSON. *Glass*, **6** [11], 463–69 (1929).—The choice of various kinds of fuel to be used in a gas producer is discussed giving the advantages and disadvantages of the various common fuels such as coke, bituminous and anthracite coal, wood, and lignite. The physical properties which are essential to a good producer type of coal are given. A producer coal should be of a free-burning nature with little tendency to cake, and should not form a hard coke difficult to reduce. The ash should have a high fusion temperature and should contain low lime, sulphur, and pyrites which cause fluxing at a low temperature. It is best, wherever furnace design permits, to use the gas at a temperature as near as possible to that at which it leaves the producer, utilizing to the full its sensible heat, tarry vapors, and minute carbon particles, which is very beneficial. Sometimes it is necessary to build the producer as a part of the furnace to obtain high temperatures. The various types of producers are compared and described giving the points of advantage or disadvantage as the case may be. The mechanical type seems to far outclass the hand-operated producer. Coal and gas analysis are given for a producer in operation supplying a continuous rolling-mill furnace. **II.** *Ibid.*, **6** [12], 511–14 (1929).—Practical hints on efficient operation are given with particular attention to the causes of an uneven temperature in the firebed. If the firebed has an uneven temperature on top this can be due to three causes only: (*a*) an uneven ashbed, (*b*) channeling, and (*c*) uneven distribution of the coal feed. The rate of gas production should be regulated entirely by altering the pressure of the blast to give the desired quantity of gas. The feeds should be regulated by the temperature of the fuelbed which is controlled by a pyrometer placed in the gas outlet. The design of the mains depends on the layout of the producer plant in relation to the furnaces, and the question of a central battery operating furnaces from a common main or the "unit" system enters into this. If the main is well insulated, the temperature drop per 100 ft. is decidedly much lower than when the main is exposed to the cold atmosphere. An efficient type of dust collector is shown and described. Methods of cleaning the flues are taken up giving helpful suggestions and showing wherein the old methods are inefficient. For the smaller plants up to three producers, a single elevator distributing by a gate into one of the chutes serving each bunker is the most economical plant for the handling of coal if the elevator is of sound construction. Grab cranes may be used for larger plants. Steam and air blast are discussed and also methods for automatic gas-pressure regulation. Instruments are discussed such as recording pyrometers and gas-pressure gages. O.E.M.

Thermal study of formation of gas from coal. FRITZ SCHUSTER. *Gas und Wasserfach*, 713–18 (1929); *Gas Age-Rec.*, **64** [24], 861–64 (1929).—The so-called Sankey or Rankin diagrams are used to depict graphically technical processes of a thermal nature. These diagrams are pictures of the flow of heat which afford an insight into the distribution of the heat supplied to a process and flowing away from it in unchanged form after its completion. They assist in recognizing certain avoidable heat losses, and under certain conditions they are also valuable in pointing out sources of heat which can still be used and thus render the process more efficient from the thermal standpoint. S. has developed such a diagram for the flow of heat for the gasmaking process. This diagram is intended to represent the conditions that exist in the average modern gas

works, and for this reason average figures had to be used. Various gas works, which operate commercially, will find that they do not agree with these average figures within certain limits, and their practice may be better or worse than what the latter represents. Nevertheless, the figures which they derive from their own practical operations can easily be used, according to the example which S. works out, to draw a diagram of heat flow corresponding to them. F.P.H.

Twenty-cent gas now available for industrial plants. ANON. *Ceram. Ind.*, **14** [1], 74 (1930).—The Dover Boiler Works, New York City, claims that its clear producer gas plants make 20-cent gas readily available in districts that can be supplied with the cheaper grades of buckwheat coal and coke breeze at prices to $5 a gross ton. The producer built by this company is fully water-jacketed and is said to have particularly efficient rotary grates. These grates have no perforations through which extremely fine fuel can be wasted and the elimination of water seals makes it practicable to carry blast pressures of several pounds, if necessary, to overcome the resistance of very small fuels. F.P.H.

Firing with gas. ANON. *Clay-Worker*, **92** [6], 437 (1929).—Three rectangular kilns with a capacity of 135 M standard brick each have been equipped for gas firing by the Alliance Clay Products Co. (Alliance, Ohio). Each kiln has 20 burners, ten on each side, and two turbine blowers are used, one on either side in the center of the kiln. A Bristol recording pressure gage is used for recording gas pressure and Thwing pyrometers are used for recording temperatures. Merriam mercury pressure gages are used for indicating both air and gas pressures at the kiln. The use of gas has reduced the firing time approximately 48 hours. The ware has a better color, there being no flashed edges which occur so frequently with coal firing. This method reduces percentage of bats and seconds, the temperature is more constant and there is a saving over ash and coal handling. No clinkering saves time and repairs on kilns. Illustrated. E.J.V.

Production and substitution of manufactured gas for natural gas. WILLIAM W. ODELL. Bur. Mines, *Bull.*, No. 301, 179 pp. (1929).—In the realization that the supply of natural gas is not inexhaustible and manufactured gas will be used as a substitute in those localities at present using the natural gas, it is believed timely to consider some of the problems with which the industry will be confronted, the aim being to note the following points: (1) raw materials that may be used for making gas, their availability, and probable future costs; (2) location of supply of natural gas with respect to population centers; (3) probable effect of diminishing supply of natural gas upon the production cost of city gas per 1000 cu. ft.; (4) general effect of substituting a manufactured gas of lower calorific value for natural gas; (5) reasons for gas-rate increase; (6) relative fuel values of natural and manufactured gas and other fuels; (7) relation of certain chemical industries to manufactured gas process; (8) variations in customer demand for gas; (9) possibilities in economical generation of manufactured substitute gas; and (10) tendency toward lower calorific standards in the manufactured-gas industry and its relation to substitute gas. These general conditions have been studied and are discussed to aid in the better utilization of our fuel resources and the production of low-priced manufactured gas. R.A.H.

Combination firing of blast-furnace gas and pulverized coal. F. G. CUTLER. *Trans. Amer. Soc. Mech. Eng.*, **50** [15] 102–106 (1928).—The Ensley blast-furnace plant of the Tenn. Coal, Iron & Railroad Co., consisting of six blast furnaces, has been operating for about five years a boiler plant using pulverized coal to supplement blast-furnace gas firing. Some of the results obtained from this installation are given and discussed in detail. E.P.R.

PATENTS

Combustion-chamber construction. GEORGE BRAIN. U. S. 1,741,147, Dec. 31,

1929. As a new article of manufacture, an integral part of nonmetallic refractory material adapted to form the major portion at least of a longitudinal section of an elongated combustion chamber and formed with channels in its walls adapted to receive fluid absorbing heat from the walls of the channels.

Roofs of brick kilns. J. S. WHITEHOUSE. Brit. 320,741, Dec. 11, 1929. In a multichambered kiln of the archless type a roof consisting of brick removably strung onto fixed girders or like flanged supports is arranged to extend over the chambers, and connecting passages between the chambers are formed in the roof.

Furnace walls. CARBORUNDUM CO., LTD. Brit. 321,281, Dec. 27, 1929. The furnace lining is cooled to a temperature at least 100°C below the flame temperature but above 400°C, and water-circulating pipes may be provided within the air-circulating passages in the wall.

Geology

Ceramic resources of Virginia and their development. J. W. WHITTEMORE. *Bull. Amer. Ceram. Soc.*, **8** [12], 355–57 (1929).—Virginia may be divided into three sections in regard to its ceramic resources: the coastal plain, Piedmont, and mountain areas. The types of ceramic materials found in each of these sections are enumerated and briefly discussed. Statistics are reported regarding the production of ceramic raw materials and finished products. The purposes in mind when the Ceramic Eng. Dept. was established at Virginia Polytechnic Inst. in 1928 are discussed. A description of the equipment being installed in the ceramic laboratory is given. After some survey projects have been completed, courses will be offered in ceramic engineering. Results obtained to date are listed. E.J.V.

Geophysical abstracts. VIII. F. W. LEE. Bur. Mines, *Repts. of Invest.*, No. 6224 (1929).—Continuation of a series of papers outlining the contents of current articles on geophysical prospecting. For previous abstract see *Ceram. Abs.*, **9** [2], (1930). R.A.H.

Bentonite in southern Arkansas. ANON. *Rock Prod.*, **32** [24], 66 (1929).—Three bentonite deposits have been found in the coastal plain region of southern Ark. See also *Ceram. Abs.*, **8** [11], 840 (1929). W.W.M.

Quantity and value of mineral products of U.S. for 1928. FRANK J. KATZ AND MARTHA B. CLARK. Bur. Mines, *Mineral Resources of U.S.*, Part I, 115 pp. (1929).—The combined output of all mineral products may be characterized as one of little change and that in the direction of slightly lower rates of production and price levels. The mineral fuels as a group showed a decrease of 5.5% in total value of products. The total value of metallic products of the mines of the U.S. in 1928 was about 5% greater than that in 1927, but was well below the value in 1926. The total value of nonmetallic mineral products (not including fuels) in 1928 decreased moderately as the result of a general decline in prices which offset prevailing increases in quantity of production. R.A.H.

Canadian nonmetallic minerals. BUREAU OF STATISTICS. *Can. Chem. Met.*, **13** [12], 31 (1929).—Figures are given showing the domestic output of fluorspar, magnesite, silica brick, sodium carbonate crystals, and sodium sulphate during 1928. See also *Ceram. Abs.*, **8** [9], 679 (1929). E.J.V.

Feldspar production increases. ANON. *Can. Chem. Met.*, **13** [12], 32 (1929).—An increase of 7% in Canadian feldspar production is indicated by the latest statistics on this industry. Last year, the Canadian output amounted to 31,897 T. worth $284,942 as compared with 29,849 T. worth $259,151 in 1927. Exports (principally to the U.S.) totaled 28,101 T. worth $230,946. Imports were 3171 T. valued at $53,818. E.J.V.

Mica. I. General information. W. M. MYERS. Bur. Mines, *Information Circ.*, No. 6205, 37 pp. (1929).—The report is a compilation under one heading of general information relating to mica. R.A.H.

High-pressure synthesis of carbonates and silicates. W. EITEL AND W. SKALIKO. *Naturwissenschaften*, **17** [18], 316–19 (1929).—Description of an apparatus capable of reaching pressures of 1200 to 1300 atm. Various carbonates were synthesized in it and attempts will be made to study the glasses of the carbonates. L.T.B.

Activity of iron-hydroxides. GUSTAV HUTTIG AND ANTON ZÖRNER. *Z. anorg. allgem. Chem.*, **184** [1], 181–92(1929).—The activity as measured by catalytic action of the hydroxide in decomposing hydrogen peroxide was studied as a function of the age, water-content, preparation, and aging processes. L.T.B.

Periclase from Crestmore, Calif. AUSTIN F. ROGERS. *Amer. Mineralogist*, **14** [12], 462–69 (1929). F.P.H.

Structures of sulphides and sulphosalts. JOHN W. GRUNER. *Amer. Mineralogist*, **14** [12], 470–80 (1929).—G. summarizes the existing data on the structures of sulphides and sulphosalts as follows: (1) Sulphosalts do not differ structurally from sulphides except that two or more metals in them occupy at least two structurally non-equivalent positions. This causes minerals such as pentlandite to come under the classification of sulphosalts. (2) Structural radicals are not distinguishable except in the pyrite group, pentlandite, and sulvanite. (3) The most common arrangements of the S atoms in sulphides and sulphosalts seem to be those involving close packing of cubic face-centered (cannon ball fashion) and hexagonal types. G. believes that slightly distorted close packing of this nature may also be expected in orthorhombic sulphides or sulphosalts. Oxygen atoms (or ions) also show these arrangements in many oxides and silicates as shown especially by W. L. Bragg. (4) With the exception of the layer lattices of the molybdenite group, most sulphides and sulphosalts have their S atoms arranged at the corners of regular or slightly distorted tetrahedrons. This necessarily follows in a close-packed structure. S tetrahedrons also prevail in other structures. The size of these tetrahedrons is determined by the radii of the metal atoms which are associated with them. The shortest edge seems to be in pyrite (3.09 Å), while in Na_2S the large radius of Na increases the length of the edge to 4.62 Å. F.P.H.

Barite in California. WALTER BRADLEY. Amer. Inst. Mining Met. Eng., *Tech. Pub.*, No. 266; *Mining and Met.*, **11** [277], 18 (1930). F.P.H.

Mining and processing silica. H. R. KNIGHT. *Eng. Mining Jour.*, **128** [24], 925 (1929).—Mining and milling operations in Arkansas are briefly described. E.C.C.

Clay deposits in Nova Scotia. ANON. *Clay-Worker*, **93** [1], 66 (1930).—Exploitation of the clay deposits in Nova Scotia will be undertaken in the near future if negotiations on the behalf of the Sodalumina Chemical Corp. of Canada are successfully concluded. It is proposed to utilize the extensive clay deposits of the province for manufacturing purposes and a plant will be erected in that district for this purpose. E.J.V.

Origin of moldavite. J. CHLOUPEK. *Naturwissenschaften*, **17** [30], 598–600 (1929).—Moldavite is a glass occurring in a certain section of Bohemia. It is almost pure aluminum silicate melting between 1300°C and 1400°C. C. believes that it originated as a glass meteor. Photographs of the forms in which it occurs are included. L.T.B.

Ochers and mineral pigments of the Pacific northwest. HEWITT WILSON. Bur. Mines, *Bull.*, No. 304, 74 pp. (1929).—A review is given of the nomenclature, sources, imports, statistics, common methods of preparation, and testing of mineral pigments. A description of the Deer Park-Spokane colored clay district and the laboratory methods of preparation of these colored clays, ochers, and siennas follows. The mineral pigments

were prepared by washing or grinding the original material as received and by calcination of the yellow ocher and brown sienna with and without manganese dioxide to produce red, brown, and black colors. These prepared powders were tested for fineness, oil absorption, and color as compared with well-known brands of commercial pigments. The results are favorable in some cases and unfavorable in others. There is considerable variation in the physical properties and color of commercial pigments, and the nomenclature of the different colors is still in the hands of the individual manufacturers. R.A.H.

Investigations in ceramics and road materials, 1927. DEPT. OF MINES, Ottawa, No. 697; *Can. Chem. Met.*, **13** [13], 52 (1929); for abstract see *Ceram. Abs.*, **9** [1], 37 (1930). E.J.V.

BOOKS

Mineral Resources of the U.S., 1926. Part I. Metals. 774 pp. $1.25. Published by BUREAU OF MINES. **Part II. Nonmetals.** 675 pp. $1.00. R.A.H.

Elements of Mineralogy. FRANK RUTLEY. Reviewed by H. H. Read. 22nd ed., 394 pp. Thos. Murby and Co., London. Price $2.50. Reviewed in *Amer. Mineralogist*, **14** [12], 488 (1929). F.P.H.

Chemistry and Physics

Chemical researches on refractory materials. I. II. H. I. VON ROHEN. *Ber. Chemikerausschuss*, Nos. 48 and 50; *Tonind.-Ztg.*, **53** [85], 1518 (1929).—The first part deals with methods for analyzing quarzites, silicates, grog, and clay. The procedures given by the Chemical Comm. of the Society of German Iron Smelters are not to be considered as rules, but have been worked out as reliable methods in order to settle existing disagreements. Certain important points are taken up in connection with the methods recommended. There follows the determination of silicic acid by evaporation with fluoric acid, taking care to have a sufficient excess of sulphuric acid to prevent volatilization of titanium and aluminum. If the substance contains calcium oxide, the quantity of sulphuric acid taken up by the formation of calcium sulphate in the residue evaporated to dryness must be ascertained. The reduction procedure with $TiCl_3$ is selected to find the iron content, and the colorimetric method for titanium. Aluminum can be separated out as a phosphate. Determining the alkalis by indirect methods gave great variation in results so that after weighing together as chlorides the potassium was determined directly. The second part contains methods for analyzing raw and fired dolomite and magnesite. A solution is made by using concentrated HCl, the silicic acid is separated out by evaporation and the filtrate examined by usual methods. When the quantity of the insoluble residue is too great to complete the analysis with hydrofluoric acid, the sodium treatment is used. The results of the different researches are tabulated. M.V.K.

Researches of one-component system SiO_2. III. Stability of quartz, tridymite, and cristobalite. C. J. VAN NIEUWENBURG. *Rec. trav. chim.*, **48**, 402–405 (1929); *Tonind.-Ztg.*, **53** [94], 1665 (1929); for abstract see *Ceram. Abs.*, **8** [8], 605 (1929). M.V.K.

Studies on aluminium silicates containing water. II. Dehydrating vapor-pressure of kaolin. C. J. VAN NIEUWENBERG AND H. A. J. PIETERS. *Rec. trav. chim.*, **48**, 406–16 (1929); *Tonind.-Ztg.*, **53** [94], 1665 (1929); for abstract see *Ceram. Abs.*, **8** [8], 605 (1929). M.V.K.

International scale of temperature. ANON. *Le Génie Civil*, December, 1928; *Rev. générale d'electricité*, November, 1928; abstracted in *Chaleur ind.*, **10**, 261 (1929). A.J.M.

Syneresis of silica gel. ANON. Dept. Sci. Ind. Research [London], *Rept. Bldg.*

Research Board, No. 53 (1928).—The gels were prepared by adding water glass to acetic or hydrochloric acid solutions, and allowing the resulting sols to set. They were not dialized, but all gels were prepared to contain the same amount of electrolyte. Results indicate that the contraction of the solid gel was, within 1 part in 36,000, equal to the volume of the liquid syneresed. This shows that syneresis consists in the elimination of free water due to contraction of the gel. If the process consisted in the gradual decomposition of hydrated silica micellae, alteration in volume of the sum of the volume of water and gel would occur. The volume contraction when syneresis has ceased is of the order of 25% of the original volume of the gel, and there is still a large quantity of enmeshed water in the gel. As the silica content of the gel increases, the evolution of syneretic liquid is more rapid and more liquid is exuded. The velocity of syneresis doubles itself for every 10°C rise in temperature. The more alkaline a sol is the more rapidly it sets, and the greater its initial velocity of syneresis. W.L.

X-ray applications in every-day engineering problems. GEO. L. CLARK. *Trans. Amer. Soc. Mech. Eng.*, **51** [1] 27–28 (1929).—In every respect X-rays are identical with ordinary light except that the wave-lengths are only 1/10,000 as great, on the average, as visible light. They are electromagnetic vibrations propagated as waves or as tiny bundles of radiant energy through space without transference of matter. X-rays, the cosmic rays which come from the far reaches of the universe and are able to penetrate 18 ft. of lead, the γ-rays from radium, the ultra-violet, infra-red, and radio waves are all like light except in wave-length. Because X-rays are shorter than light they are more penetrating through materials opaque to light and should be associated with a finer subdivision of matter than is apparent by examination in visible radiation. X-rays lead from information concerning the interior gross structures of material to knowledge of ultimate fine structures far beyond the power of any microscope. Nature has built all solid crystalline matter according to a plan so that all atoms and molecules are on parallel planes which are spaced at distances comparing with the short wave-lengths of X-rays. Thus crystals, each one in its own definite characteristic fashion, diffract X-rays just as finely ruled lines on glass diffract ordinary light. The size, shape, and constitution of the single brick is determined in an apparently homogeneous structure hundreds of millions of times larger. If this brick is deformed slightly by stress the X-ray patterns indicate it. So rapid has been the growth of this chemical science of X-rays that more than 500 kinds of crystals have been singularly analyzed ranging in complexity from common salt or aluminum to very complex silicate minerals and organic compounds. A few representative X-ray studies on nonmetallic materials now being made in the laboratory at the University of Ill. and elsewhere are as follows. (1) *Asbestos.* A clear differentiation between numerous varieties appearing outwardly the same but differing widely in practical behavior and a method of identifying the mines from various specimens of the same type. (2) *Lime.* Discovery of the cause of plasticity and methods to render nonplastic lime useful. (3) *Enamels and Pigments.* Composition, particle size, and crystallization as functions of covering power, tint, wear, etc., are discussed. (4) *Ceramic Materials.* Constitutional transformations and internal strains as in spark plugs are dealt with. See *Ceram. Abs.*, **9** [2], 114 (1930). E.P.R.

Set of thirty immersion media. R. C. EMMONS. *Amer. Mineralogist*, **14** [12], 482–83 (1929).—Objections to standard immersion media are many and well known. Probably one of the greatest drawbacks is the extent to which these media change in index even over a short period of time. Essential oils commonly used such as cedar oil, clove oil, etc., are natural mixtures from which the lighter constituents evaporate, leaving a gummy residue. Others in standard sets are manufactured mixtures which change index even more rapidly. The liquids listed are, as far as possible, single com-

pounds. Evaporation does not, therefore, change the index. For the liquids of higher index it is necessary to use mixtures since liquids of high index are rare. The mixtures chosen are made of very similar liquids whose boiling points are close together. Evaporation, therefore, takes place in both liquids of the mixture at almost the same rate of speed. The change in index in these liquids due to this cause is slight and seems to be at a minimum. The liquids are listed together with their boiling points, indices at room temperature, and temperature coefficients. F.P.H.

Note on determination of calcium and magnesium in aluminum. K. STEINHÄUSER. *Z. anal. Chem.*, **78,** 181–88 (1929).—The analysis involves the determination of Ca and Mg in a material which is chiefly Al but contains small quantities of Si, Fe, Cu, Zn, Pb, Mn, and Ti. A critical study of the usual methods for determining Ca and Mg has led to the following scheme of analysis: Treat 10 g. of Al shavings with 90 cc. of (1:3) NaOH solution, filter through asbestos that has been heated with concentrated H_2SO_4 and washed with water, dissolve the residue in HCl-Br, filter again through asbestos, make alkaline with NaOH and heat to boiling. To the hot solution add 30 mg. of Cu as catalyst in the form of Cu salt and boil 5 min. while introducing a stream of air impregnated with Br_2 vapors. This serves to precipitate all Mn as MnO_2 and to form a little MnO_4^-. To reduce the latter, add a little alcohol and boil 5 min. longer. Filter through asbestos or a sintered glass-filtering crucible, and wash well with dilute NaOH solution. The filtrate can be used for determining Zn and Pb. Digest the precipitate for 2 hrs. on the steam bath with 100 cc. of 0.6 *N* HNO_3, filter, and determine Ca and Mg in the filtrate. The precipitate contains MnO_2. To the filtrate add 20 cc. of 18 *N* H_2SO_4, evaporate to fumes, dilute with a little weak HCl and filter. Neutralize the H_2SO_4, make acid with AcOH, heat to 70° and add hot $(NH_4)_2C_2O_4$ to precipitate Ca. Filter off the CaC_2O_4 after 12 hrs. and, if it is contaminated with Fe, dissolve and repeat the precipitation. Evaporate the filtrate from the first CaC_2O_4 precipitate with 5 cc. of concentrated H_2SO_4 to destroy oxalate, dilute with 120 cc. of *N* HCl, add NH_4OAc until the solution is red to Congo paper and some $(NH_4)_2HPO_4$. This causes precipitation of the Fe. Filter, make strongly ammoniacal, and allow to stand overnight to precipitate $MgNH_4PO_4$. (*C.A.*)

Procedure for determination of iron with titanium trichloride. L. BRAND. *Ber. Chemikerausschuss*, No. 44; *Tonind.-Ztg.*, **53** [85], 1518 (1929).—The best and quickest way of determining iron according to Knecht and Hibbert, *i.e.*, by reduction with titaniumchloride and rhodium salt as indicator, has the disadvantage that in an ore containing copper a simultaneous reduction of copper occurs. B. overcomes this disadvantage by the use of a chromic acid salt of diphenyl carbohydrazide as indicator, as a change in color appears immediately after the reduction of iron. The copper can be detected in the same solution by the addition of rhodium salts. Only tungsten and molybdenum have an injurious effect on titration if they are present in large quantities. M.V.K.

Microscope as aid to technical analysis of clay. H. MÖHL. *Sprechsaal*, **40,** 731–34; **41,** 749–52 (1929); *Tonind.-Ztg.*, **53** [93], 1647 (1929); for abstract see *Ceram. Abs.*, **8** [9], 684 (1929). M.V.K.

Pure carbon monoxide for experimental purposes. J. G. THOMPSON. *Ind. Eng. Chem.*, **21** [4], 389–90 (1929).—T. describes the equipment and method used for obtaining fairly large quantities of carbon monoxide of high purity in the Fixed Nitrogen Research Laboratory at Washington, D. C. The principle involved depends upon the thermal decomposition of formic acid in the presence of a dehydrating agent. A complete description and diagram of the equipment are included. Analyses of the dried gas show 99.9% carbon monoxide or more. Two generators are used, the combined output being 200 cu. ft. of gas in 7 hrs. The process is continuous and the only ma-

terials expended are formic acid and electricity for the heating coils. These items represent a cost of 2.5¢ per cu. ft. of gas. The small room which houses the equipment is equipped with a large ventilating fan, independent of the main ventilating system. Apparatus for artificial resuscitation and tanks of oxygen are maintained in readiness for emergencies. R.G.M.

Sulphur gases and drier scumming. R. K. HURSH. *Brick Clay Rec.*, **75** [13], 810–12 (1929); *Clay-Worker*, **92** [6], 438–41 (1929).—Scumming due to soluble salts in clay may be corrected by proper addition of barium compounds. Scumming of drying ware occurs when sulphur gases are present in amounts less than one-half per cent, but the minimum amount which may affect the ware is not determined. Conditions which promote rapid drying, such as low humidity, rapid air movement, and high drying temperatures, decrease the scumming due to sulphur gases in the drier. Sulphate formation due to sulphur gases is largely a surface effect and is more pronounced in the early stages of drying when the surface of the ware is wet. Sulphur fumes in the drier may come from fuel and clinker left in kiln fireboxes or from the ware in the kiln. The lowest temperature at which the ware will give off the gases is about 1000°F but in cooling kilns the amount given off will become negligible at appreciably higher temperatures. Tests of gas samples from cooling kilns show a rapidly decreasing sulphur content as cooling proceeds; the amount is negligible at 1400°F and below and is approximately 0.03% at 1600°F. More heat for drying is available in many cases by connecting cooling kilns earlier, without danger of scumming by sulphur gases. E.J.V.

X-ray studies of cements. H. W. GONELL. *Zement*, **18**, 32 (1929); *Rock Prod.*, **32** [24], 109 (1929).—G. tabulates data and gives results of X-ray examination of specimens of set alumina cement, "sanded off" alumina cement, and calcium carbonate. These data are proofs that "sanding off" of an alumina cement is caused by formation of a calcium carbonate due to influence of atmospheric carbonic acid. The calcium carbonate is eliminated as a calcite-shaped crystal. W.W.M.

Gravimetric method for determination of ruthenium. RALEIGH GILCHRIST. Bur. Stand., *Jour. Research*, **3** [6], 993–1004 (1929).—A gravimetric procedure for the accurate determination of ruthenium by hydrolytic precipitation from chloride solution has been developed. A delicate test for the qualitative detection of small quantities of ruthenium, using thiourea as a reagent is described. R.A.H.

Melting, mechanical working, and some physical properties of rhodium. W. H. SWANGER. Bur. Stand., *Jour. Research*, **3** [6], 1029–40 (1929).—In continuation of the work on the platinum metals a method for the purification and technic for melting and mechanical working of rhodium has been developed. New determinations of a number of the physical constants of rhodium have been made on the specially purified material. The melting point of rhodium has been determined as 1985°C ± 10°C. R.A.H.

Free energy charts for predicting equilibrium pressures and concentrations. R. F. NIELSEN. *Ind. Eng. Chem.*, **21** [6], 568–71 (1929).—A form of chart is suggested which allows practically direct reading of physical and chemical equilibrium concentrations, if a single chart is prepared for each pure substance in question. The chart involves lines of constant pressure or concentration with temperature as abscissa and a function of the free energy as ordinate. Various suggestions are given as to methods of preparation of the charts, and their extension to ions and solutions of electrolytes. Sample charts are given for oxygen. It is believed that the construction of these charts, with suitable modifications, from available thermodynamic data or free energy equations will result in a considerable saving of time to those making frequent calculations of chemical equilibrium concentrations. R.G.M.

Society of Rheology. EDITORIAL. *Bull. Amer. Ceram. Soc.*, **9** [1], 1–3 (1930).—

The meaning of the term "rheology" is explained and the various properties with which rheologists are most concerned are enumerated. The wide application of this new science is pointed out by enumeration of some of the many types of products with which it may be connected. It is pointed out wherein this new science is applicable to ceramics and should be of interest to ceramic men. The history of the Society of Rheology and its publication, membership, and backing are briefly reviewed. E.J.V.

Charts for predicting equilibria. M. RANDALL. *Ind. Eng. Chem.*, **21** [6], 571–72 (1929).—R. presents a form of chart for use in predicting equilibria, the chart being based on the usual methods of selecting standard free energy. R.G.M.

Analysis of bauxite. G. E. F. LUNDELL AND J. I. HOFFMAN. *Rock Prod.*, **32** [24], 56 (1929); see *Ceram. Abs.*, **8** [5], 342 (1929). W.W.M.

BOOKS

Handbook of Mineral Chemistry. C. DOELTER AND H. LEITMEIER. Published by Theod. Steinkopff, Dresden; reviewed in *Tonind.-Ztg.*, **53** [84], 1502 (1929).—The authors give a comprehensive study of the origin of salt deposits, the salt deposits of Germany, and the important deposits throughout the world with their chemical composition, the uses of salt minerals and their separation into their several ingredients. Maps and outline drawings explain the text and numerous tables give information on the chemical composition of single formations. A special chapter is devoted to the fluorides of the alkalis, their synthetic preparation, and chemical and physical properties. M.V.K.

Electron Physics. J. BARTON HOAG. D. Van Nostrand Co., N. Y., 1929. 208 pp. diagrams, tables, $3.00. Reviewed in *Mining and Met.*, **11** [277], 27 (1930).—Intended to initiate students of physics to such concepts as "electron," "α-,β-, and γ-rays," "photo-electric effect," etc., by experiments that require only simple apparatus. The book presents these concepts simply, accompanied by the experiments. It follows a course in radio-activity and discharge gases given at the Univ. of Chicago. F.P.H.

Engineering Mechanics. WILLIAM BROOKE AND HUGH B. WILCOX. Bost, Ginn and Co., 1929. (Engineering Series) 320 pp., $3.20; reviewed in *Mining and Met.*, **11** [277], 27 (1930).—A concise course in fundamental principles intended for students of engineering with some knowledge of calculus, covers statics, kinematics, and dynamics. Many problems are provided. F.P.H.

Measurement and Weighing. WALTER BLOCK. (In German) 329 pp. Published by Otto Spamer, Germany. This book is especially useful for chemists. Reviewed in *Chaleur ind.*, **10**, 322 (1929). A.J.M.

PATENT

Process for producing titanium oxide. FOORD VON BICHOWSKY. U. S. 1,742,674, Jan. 7, 1930. Process of producing pure dioxide of titanium from pure reactive titanium nitrogen compounds which comprises acting upon the compounds with nitric acid in the presence of sulphuric acid.

General

Value of Canadian clay products. ANON. *Clay-Worker*, **93** [1], 27 (1930).—Production of clay products in the Dominion of Canada in 1928 has a total value of $12,381,718 compared with the previous year's total of $11,173,189. The provinces ranked as follows: Ontario, Quebec, Alberta, British Columbia, Nova Scotia, Saskatchewan, Manitoba, and New Brunswick. All the provinces except New Brunswick reported increases. Imports of clay and clay products into the country in this period amounted to $10,023,747, of which $4,179,331 came from the U.S.; $3,910,366 from the United Kingdom; $594,846 from Germany; $384,253 from France; $377,762 from Czecho-

slovakia, and $116,041 from Belgium, with minor amounts from 21 other countries. Exports from Canada amounted to $284,518. Fourteen plants which operated entirely with imported clays produced porcelain insulators, floor tile, fire brick, and refractory products. E.J.V.

Waste heat recovery. ANON. *Rock Prod.*, **32** [26], 53–58 (1929).—A waste-heat installation of Edge Moor Iron Co. design, generates power to run the entire Security plant of the North American Cement Corp. When all 5 kilns are in operation 20% of the power output is sold to the local power company. Illustrated. W.W.M.

German Feldspar and Kaolin Company, Seilitz. PAUL WERTHNER. *Keramos*, **8** [22], 825–38 (1929).—A detailed description is given of the plant and products produced. F.P.H.

Christopher Krautheim. ANON. *Keramos*, **8** [23], 871 (1929).—A short biographical sketch is given. F.P.H.

Bavarian feldspar and Bauscher pegmatite. ANON. *Keramos*, **8** [23], 885–91 (1929).—The feldspar mine of the Schmidt, Retsch and Co., of Wunsiedel, Bavaria, and the pegmatite mine of the Keramische Rothstoff Co., at Weiden, Bavaria, are described. The composition of the products mined is given and the history and geology of the districts are discussed. F.P.H.

Dynamites: their propulsive strength, rate of detonation, and poisonous gases evolved. N. A. TOLCH AND G. ST. J. PERROTT. Bur. Mines, *Rept. of Invest.*, No. 2975 (1929).—The report presents results of ballistic-pendulum, Bichel gage, and other tests of straight ammonia and gelatin dynamites, black blasting powder, and kieselguhr. It describes types of explosives, discusses tests, and contains tabular data showing average chemical analyses of explosives, results of strength tests, comparative strength based on nitroglycerin content of equivalent straight dynamites, rates of detonation, and average analyses of products of detonation. R.A.H.

American Face Brick Association. ANON. *Brick Clay Rec.*, **75** [13], 823–25 (1929); *Clay-Worker*, **92** [6], 430–33 (1929).—A plan, calling for the largest expenditure of money and effort ever available to the Association, was approved at the convention in Miss., in Dec., 1929. The plan calls for dues of 40¢ per M and will make available for advertising and general promotional effort about $500,000. The plan includes the adoption of a label or trademark by the Association to be used only by members and certifying to the quality and integrity of their product. It is the purpose to advertise the trademark widely in order to create a preference in the public mind for brick bearing the label, "Inspected—Approved Face Brick." E.J.V.

National Paving Brick Mfrs'. Assn. ANON. *Brick Clay Rec.*, **75** [13], 826–30 (1929); *Clay-Worker*, **92** [6], 434–35(1929).—A report of the meeting held in Chicago, Dec., 1929, and brief summaries of the addresses delivered are given. E.J.V.

Surveying Pennsylvanian ceramic industries. ANON. *Glass Ind.*, **11** [1], 21–22 (1930).—J. B. Shaw, of Pennsylvania State College, sent out early in December to approximately 1100 ceramic manufacturers a questionnaire designed to produce information from which a survey of the ceramic industries of Pa. may be prepared. The purpose of the questionnaire is to obtain pertinent data relative to every producer of ceramic raw materials and manufactured products in the state. A description of each plant will be listed separately as well as tables compiled giving total values. E.J.V.

Commercial standard for ground feldspar. ANON. *Glass Ind.*, **11** [1], 13–14 (1930).—Details of a proposed commercial standard for feldspar to be acted upon by the Feldspar Grinders Inst. are given. These include general requirements, detail requirements of a physical classification based on fineness of grinding, chemical classification based on composition as it influences use, and standard methods of physical and chemical testing. E.J.V.

Swedish Glass Association. ANON. *Pottery Gaz.*, **55** [631], 75 (1930).—In order to improve the situation of serious depression and keen competition from foreign works, fifteen of the most important Swedish producers of household and crystal glass have formed an association called Svenska Glasbrukens Exportfoerening, which will be the selling agency for the works on the export market. At first activity will be confined to the British market, with possible extension to other markets later on. E.J.V.

Our Abstracts. EDITORIAL. *Bull. Amer. Ceram. Soc.*, **8** [12], 349–50 (1929).—A table showing the number of abstracts published during the past three years is given with detailed information regarding the methods used in collecting and editing these abstracts to insure their completeness. It is pointed out that while this is an expensive phase of activity engaged in by the AMERICAN CERAMIC SOCIETY, it is hoped to increase this service as the means are provided for so doing. E.J.V.

Spend that you may gain. EDITORIAL. *Bull. Amer. Ceram. Soc.*, **9** [1], 3–4 (1930).—It is pointed out that judicious spending is worthwhile, and the expense of a trip to an Annual Meeting of an organization such as the AMERICAN CERAMIC SOCIETY is of that type inasmuch as there is a definite benefit derived from such spending. E.J.V.

Progress of industrial heating by oil circulation. A. B. MCKECHNIE. *Ind. Eng. Chem.*, **21** [5], 496–98 (1929).—Industrial heating by oil circulation has been successfully applied to high-temperature heating processes in many industries for about 15 years. This type of heating system has several advantages, the most important being (1) resistance to corrosion, (2) moving parts confined to the circulating oil and pump, (3) operation under extremely low pressures, and (4) low depreciation over a long period of time. R.G.M.

An "inside story" of ceramics.* T. S. CURTIS. A popular discussion of the physical structure of ceramic bodies as seen through the microscope. By means of accelerated motion pictures, the progress of glass and crystal formation is depicted, showing the relation of one to the other, and delineating the function of quartz, feldspar, and clay. The use of inert substitutes for quartz and the properties resulting from such substitution are briefly touched upon. Body structures as seen through the microscope are shown by means of natural color photomicrographs.

Bonus methods of wage payment as related to production.* H. R. STRAIGHT. The factors entering into the set-up of a bonus system designed to increase production together with lower costs, decrease in labor turn-over, and maintaining the quality up to standard are discussed.

Selection and training of foremen.* ROBERT TWELLS. The position of foreman is of great importance to a company. As such it should be filled by a man having a high order of natural ability combined with specialized training. Prospective foremen should be selected and trained long before any vacancy actually occurs. Methods of accomplishing this are discussed.

Wage methods beneficial to both employer and employee as applied at Champion Porcelain Company.* HENRY J. MITCHELL. Applying wage methods whereby the employer gained greatly by deduction in scrap and deduction in labor turnover. The employee gained through wage increase and more sanitary conditions.

Wage incentive methods used in sanitary pottery industry.* P. D. HELSER. The application of wage incentive and bonus systems in the manufacture of sanitary pottery.

Wage incentive methods used in dry-processed enameled iron industry.* FRANK

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*Paper presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Toronto, Ont., February, 1930. When this paper is published reference will be given.

B. MAHONEY. The application of piecework methods to the manufacture of enameled cast iron will be discussed.

Simplified costs for glass plant operations. III. D. D. LILLEY. *Ceram. Ind.*, **14** [1], 56–60 (1930).—In Part I, an effort was made to point out the functions of a cost system; in Part II, the fundamentals for accurate costs were discussed. The actual distribution of the cost elements and the application of the cost to the finished product are discussed in Part III in this article. For previous abstract see *Ceram. Abs.*, **9** [2], 94 (1930). F.P.H.

The use of one or several kinds of clay. ANON. *Tonind.-Ztg.*, **53** [84], 1497 (1929).—A discussion as to whether the desired properties can be obtained in heavy ceramic masses by using only one kind of clay with the thinning agent (sand, pulverized brick, or grog) instead of several kinds of clays as is customary to insure better quality. This can be done successfully only when a very careful control of every process is possible, but in the case of a plant with a clay consumption of 50 to 80 cm. per day it is out of the question. M.V.K.

Power-plant substructure problems. J. C. SANDERSON. *Trans. Amer. Soc. Mech. Eng.*, **51** [1], 5–6 (1929).—Varying conditions that are encountered in power-plant substructures are illustrated by discussing the problems that arose in the construction of four power plants at Mexico City, Pekin, Ill., Cincinnati, Ohio, and Chicago, Ill. The first was on soil of low-bearing capacity, the second in water-bearing sand with a special cofferdam construction, the third required a deep foundation on water-bearing gravel, and the fourth was on a clay foundation. E.P.R.

Heating water by the thermo-siphon. F. GILLEBEERT. *Chaleur ind.*, **10**, 247–50 (1929).—The mathematical theory is given. A.J.M.

Sales budget. J. J. BERLINER. *Brick Clay Rec.*, **76** [1], 48–52 (1930).—Business men should of necessity estimate the probable sales of their business for each season or fiscal period. These estimates may be made very simply and be recorded quite informally, or they may be made as the result of a specialized analysis of all the factors involved and presented by means of a formal report. Methods of preparing the sales budget, and reasons for having various items included are explained. E.J.V.

Application of powdered coal to small boilers of industrial plants. HENRY KREISINGER. *Trans. Amer. Soc. Mech. Eng.*, **50** [8], 27–32 (1928).—K. points out that improvement of small plant efficiency is generally possible through the use of pulverized coal firing. Factors causing poor combustion conditions are enumerated. Several typical installations of powdered coal under small steam boilers of industrial plants are discussed and the method of operation calculated to produce best results is given. Complete information in tabular form is given for one installation, showing size of boiler, furnace dimensions, type of burners, operation results, etc. E.P.R.

Suggestions for offering bids. ANON. *Tonind.-Ztg.*, **53** [82], 1463–64 (1929).—The manufacturer of ceramic products should be furnished with the following data and information by raw material merchants who are offering bids: (1) analysis of residue and quality after sifting through 90- and 490-mesh sieves, (2) soluble salt content, (3) carbonate content, (4) water content, (5) per cent of shrinkage on drying, and (6) technical firing properties, (*a*) total shrinkage by firing, (*b*) absorption of water and colors at different firing temperatures, (*c*) sintering and hardening temperatures, and (*d*) softening. M.V.K.

Highest chimney in Europe of clinker construction. ANON. *Tonind.-Ztg.*, **53** [97], 1713 (1929).—Chimney of the electric plant Nord in Leipzig, Germany, has a total height of 158 m. The height of the concrete base is 33 m. and the chimney column, 123 m. The oscillations of the chimney amount to an average of 10 to 15 cm. and in a strong wind, not more than 20 cm. M.V.K.

Fire brick and glazed and enameled ware improved by study of manufacturing methods. HENRY D. HUBBARD. *Commercial Standards Monthly*, **6** [6], 159–61 (1929).—Many kinds of clay products are mixed, formed, and dried in the laboratories and kiln houses of the Bureau of Standards. Giant clay pots are used in melting the ingredients and making optical glass. An unusual product is the Marquardt tubing made of fine clay and such other materials as alumina, in 6-ft. lengths, thin as fine spaghetti with a bore fine as a needle. Among the subjects of researches and publications concerning them which the Bureau has completed are (1) fire brick, their manufacture, properties, uses, and specifications; (2) use of the interferometer in measuring thermal expansion of ceramic materials; (3) testing of clay refractories; (4) melting points of fire brick; (5) function of time in vitrifying clays; (6) dehydration of clays; (7) effect of overfiring upon the structure of clays; (8) use of sodium salts in purifying clays and in the casting process; (9) properties of some European plastic fire clays; (10) properties of American bone clays and their use in graphite crucibles and glass pots; and (11) porosity and volume changes of clay fire brick at furnace temperatures. Another type of research is the study of discoloration of brick walls, known as efflorescence. A fundamental type of research comprises the experimental studies of the materials other than clays entering into pottery and other clay products. Studies have recently been made of crazing of glazed ware after extended service. Experimental research dealing with fishscaling of enameled metalware was conducted in seeking a remedy for this defect. E.J.V.

Economics of water vs. steam power. GEO. A. ORROK. *Mech. Eng.*, **51** [12], 917–20 (1929). E.A.H.

Operation and control of boiler feedwater purification systems. S. T. POWELL. *Mech. Eng.*, **51** [12], 935–40 (1929). E.A.H.

Recent research on thermal properties of steam. HARVEY N. DAVIS AND JOSEPH H. KEENAN. *Mech. Eng.*, **51** [12], 921–31 (1929). E.A.H.

Recent developments in the nonmetallic mineral industries. OLIVER BOWLES. *Mining and Met.*, **11** [277], 37–40 (1930).—Recent important technical advances are described. The outstanding developments in the cement industry may be enumerated as follows: (1) trend toward higher early-strength cements involving a higher lime content and finer grinding; (2) a tendency toward wider use of labor-saving devices which have reduced the man-hours per barrel to 0.30 or 0.25, whereas a short time ago 0.50 man-hour per barrel was considered highly efficient; (3) a reduction in fuel consumption in wet-process mills; and (4) improvements in coolers and grinding equipment. As feldspar is always associated with other minerals, notably quartz, the preparation of a dependable uniform product has always been difficult. Notable improvements are found in the more recently built grinding mills. Methods of sampling similar to those used at custom smelters for the metallic ores are employed to determine the chemical composition of the crude feldspar. A series of bins or silos are provided, each containing material of uniform and known composition. Belt conveyers equipped with poidometers enable the operator to draw off a desired amount from any bin and thus prepare a ground feldspar to suit any specification within the limits of his raw materials. The substitution of clay for feldspar in glassmaking may have some effect on market demands. The necessary alumina is contained in larger proportion in clay than in feldspar, and the alkali supplied by the feldspar may be added in the form of soda ash. Some glass plants are now using clay instead of feldspar. F.P.H.

Progress toward direct firing of boilers with producer gas. WILLIAM B. CHAPMAN. *Trans. Amer. Soc. Mech. Eng.*, **50** [33], 33–36 (1928).—This fuel is claimed to have all the advantages of pulverized coal and atomized oil without any of the disadvantages.

The merit possessed by oil or pulverized coal is that they float and burn in suspension as an "imitation gas." E.P.R.

General trend in steam turbine development. ERNEST L. ROBINSON. *Blast Fur. Steel Plant*, **17** [12], 1825–29 (1929).—Results that have been attained through improvements in steam utilization in the production of power by the steam turbine are outlined. F.P.H.

Educating the plant superintendent. F. A. KIRKPATRICK. *Ceram. Ind.*, **14** [1], 37–38 (1930). F.P.H.

Engineers in American life. L. W. WALLACE AND J. E. HANNUM. *Mech. Eng.*, **51** [12], 899–904 (1929). E.A.H.

Review of glass industry during 1929. ANON. *Nat. Glass Budget*, **45** [35], 3 (1929).—Production and demand for plate glass both established new high records during year 1929. The rolled and wired glass branch of the industry had its unsatisfactory period but ended in fair shape. Good demand prevailed throughout the year for glass containers and manufacturers of flint glassware were kept busy. Concerning the outlook for 1930, reports from dependable authorities agree that fundamental business conditions are sound. E.P.R.

Short course in ceramics at University of Illinois. ANON. *Amer. Glass Rev.*, **49** [11], 22 (1930); see *Bull. Amer. Ceram. Soc.*, **9** [1], 8–11 (1930). E.P.R.

Fifty-first Annual Meeting of the U. S. Potters' Assn., Cleveland, Ohio. ANON. *Ceram. Ind.*, **14** [1], 66–70 (1930). F.P.H.

Feldspar Grinders Institute Meeting in Atlantic City. ANON. *Amer. Glass Rev.*, **49** [11], 21 (1930). E.P.R.

Wedgwood Bicentenary celebrations. ANON. *Pottery Gaz.*, **55** [631], 100–102 (1930); see *Bull. Amer. Ceram. Soc.*, **9** [1], 17–18 (1930). E.J.V.

English Ceramic Society's visit to America. FRANK WEST. *Refrac. Jour.*, **5** [51], 79–82 (1929).—This paper was illustrated with lantern slides and a cinema, was given by W. at Sheffield, before members of the Refractories Assn. See also *Ceram. Abs.*, **8** [9], 695 (1929). E.P.R.

Potteries of England. ANON. *Pottery Gaz.*, **55** [631], 103–107 (1930).—In connection with the Wedgwood Bicentenary celebration there will be opportunity for visitors to visit the North Staffordshire Potteries. Descriptions of the potteries and towns of Longton and Fenton and a map showing the relative positions of a few of the "show places" of England are presented. E.J.V.

Homer Laughlin China Co. ANON. *Crockery Glass Jour.*, **107** [12], 106–107 (1930); for abstract see *Ceram. Abs.*, **8** [10], 755 (1929). E.P.R.

Westmoreland Glass Co. ALDEN WELLES. *Crockery Glass Jour.*, **108** [1], 40–43 (1930).—A brief history of the life of the plant is given together with a detailed description of many of their glassware products. E.P.R.

Corundite Refractories acquires holdings of Imperial Fire Brick Co. ANON. *Amer. Glass Rev.*, **49** [13], 13 (1930).—An important development in the refractory industry is presaged by the recent announcement that Corundite Refractories, Inc., has acquired by outright purchase the plant and holdings of the Imperial Fire Brick Co. (Dover, Ohio). E.P.R.

Soda ash subsidy in Japan. ANON. *Amer. Glass Rev.*, **49** [11], 34 (1930).—The Asahi Glass Co. and the Japan Soda Co. are expected to be subsidized for 4 years by the Japanese government to the extent of 22 sen (approximately 10 cents) for each 132 lbs. of salt used in making soda ash. E.P.R.

BOOKS

Graphical Methods for Study of Discontinuously Operating Heating and Refrigerat-

ing Installations. A. NESSI AND L. NISOLLE. (In French) 168 pp., 49 figs., 17 plates. Published by Dunod, Paris; reviewed in *Chaleur ind.*, **10,** 320 (1929). A.J.M.

Boiler Furnace for Lignite. LENHART. (In German) 115 pp. Published by Julius Springer, Berlin. Reviewed in *Chaleur ind.*, **10,** 322 (1929). A.J.M.

Book Review

Transition of Heat in Industry. ALFRED SCHACK. 411 pp. Published by Verlag Stahleisen m.b.H., Düsseldorf, 1929. S. gives a very complete and clear exposition of the simplest and most accurate theories and formulas for calculating the transfer of heat and the coefficient of heat transmission for solids, liquids, and gases and their practical application in industry. The first part deals with the transfer of heat by conduction in both constant and variable heat currents. Simplified calculations of the heat conductivity of walls, pipes, and tubes are given. S. takes up heat transfer by convection with the measurements for free and forced currents of liquids and gases. This is followed by a discussion of the transfer of heat by condensed steam. Then, heat transfer by radiation with the radiation of impenetrable and penetrable bodies is given. Special chapters are devoted to the calculation of heat exchange; the heat transition in technical firing; heat transition and the loss of pressure; calculations of heat transmission of various kinds of walls and tube walls at different temperatures. Special tables give data for calculating the transfer of heat of important metals, refractory materials, liquids, gases, etc. The work is useful both to the practicing engineer and the student and is valuable as a text or reference book. M.V.K.

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Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

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EDITORIALS

THE 1931 CERAMIC EXPOSITION

On to Cleveland in February, 1931. Another large Meeting and Exposition are planned. The big Cleveland Auditorium with its several spacious meeting rooms, three theaters, and two large exposition halls will be the place. These beautiful and capacious accommodations bespeak a "big time to be had by all."

The Meeting in Toronto was heralded around the world. Weeks prior, the technical press in all the industrial countries in Europe, Asia, and South America printed the program and had editorials regarding the big way this SOCIETY is promoting ceramic art, science, and technology. The Toronto Meeting marked a very distinct advance over previous meetings in the value of the technical papers and discussions. Much value was realized by those who heard and partook in those discussions and throughout the year the benefits of the Toronto Meeting will be extended by publications in the *Journal*.

The greatest benefit from the Toronto Meeting was in the increased impetus given to coöperative promotion of ceramic research and educa-

tion. More persons are actively working together and each one has a clearer vision of the personal and industrial advantages of such coöperation.

Great as were the benefits of the Toronto Meeting, impressive as was the increased quickening of coöperative fellowship, the Chicago Meeting and Ceramic Exposition of 1929 was more beneficial. Your editor is not able to phrase reasons for the very evident benefits which accrue from a combined meeting and exposition. We know, we see, and we talk about the benefits of the wonderful Chicago Ceramic Exposition. It no doubt influenced the Toronto Meeting, making it the best attended and most beneficial Meeting in the history of the SOCIETY.

Another big boost to ceramic art, science, and technology will occur next February in Cleveland. Get set; be ready to respond coöperatively with the Cleveland ceramists.

MAKE CERAMICS KNOWN TO THE PUBLIC

In Columbus, Ohio, where the world's first collegiate ceramic school was established, and where the AMERICAN CERAMIC SOCIETY was founded, only a small percentage of the citizens know what the word "ceramic" means. There is not a large percentage of Columbus citizens who know that in America there are produced clay, glass, and glass enameled ware equal, and in many instances superior, to the ceramic ware of other countries. The public does not know the high qualities, and the varied serviceabilities of American-made ceramic ware. What is true in Columbus, is true in other centers.

Neither does the public know the superiority and the economies in the use of ceramic products. The public knows more about products that compete with ceramic ware. Ceramic manufacturers should be engaging the interest of the public. The ultimate purchasers should be impressed with the superior merits of ceramic products.

It is important that sales shows be held for the jobbers, the buyers, and the stylists. Permanent architectural exhibits are valuable as means of keeping the merits of ceramic ware before the architects and contractors. There is no thought here that these shows and exhibits for the "middleman" are not important. They should be extended. The proposal here is that ceramic manufacturers must cultivate the ultimate purchasers, the people who are in the end to possess the ware. This is a proposal of a ceramic exposition coupled with publicity by radio and press.

It is important that the public be made to know of the large variety of ceramic products and the large variety of uses which ceramic products

serve. We should not rest our case with the middleman. The middleman is not single mindedly for American ceramic ware or indeed for ceramic ware at all. It matters not to him what he sells. He meets demands. The manufacturer must create those demands with the ultimate purchaser.

PLANT PROOVING AND JOB FITTING

Fact by fact knowledge is assembled. Detached and unrelated bits of facts are discovered and prooved. Slowly but surely the relatives are found, the family assembled, and something usable produced. The end products of all research are things of commerce.

It takes trial and practice to find how to vary all of the influencing factors under shop conditions so as to make successful plant application of the laboratory developed facts. The laboratory conditions differ very much from those of factory mass production; they are more simple and under better control.

No ceramic technologist is worthy of his hire who cannot or will not see the results of his laboratory worked through to successful mass production. To merely create is not sufficient. He must produce. He must aid in the solving of all the processing problems and produce at the lowest possible cost. He must demonstrate the plant production possibilities of his laboratory creations.

Furthermore the ceramic technologist must adapt his creation to some demand of the purchasing public. Often he must create or stimulate a demand. The task of the laboratory technologist does not end until a demand is found for his laboratory creation.

We are not advocating that the laboratory technologist shall usurp the functions of the plant superintendent or that of the salesman. We do advocate that he shall consider it vital to the success of his laboratory work that he coöperate with the works and sales managers for the success of his laboratory findings. We are suggesting team work of all departments.

The laboratory man who is not concerned with factory control and with product development is dwarfing himself and not making himself most valuable to his employers. The ceramic technologist must study the purposes for which his ware may be employed, find undeveloped markets, and make new products, if need be.

One of the fields neglected by ceramic technologists is roofing. Clay and glass tile for roofs have failed very often because of improper installations. We could have more ceramic roofing tile used if our ceramic engineers would study the problems of sweating and of weight. The

tile roofs need not be damp or heavy. If ceramic technologists would give the same sort of study to the conditions of use of roofing tile, brick, glassware, and enamel ware, as have the ceramists who are successful in making spark plugs, high tension insulators, refractories, abrasives, window glass, and many other industrial and semi-industrial products, there would be a larger market for their products, a more steady and more lucrative demand for their services.

Our ceramic technologists must study their products and their possible uses to the end of creating products that will find a profitable market. They must collaborate with the engineers, the architects, and with those who use their products. They must solve the purchasers' problems and work out with them new products and new uses of products; and they must solve with the factory managers the processing problems.

PAPERS AND DISCUSSIONS

SOME DATA ON THE WHITEWARE INDUSTRY OF WEST VIRGINIA[1]

By W. A. Koehler

ABSTRACT

Most of the usual types of whiteware are manufactured in West Virginia by 24 different firms. Data are given on the kinds of body raw materials used, and their geographic sources; the materials used for glazes; lawn meshes used; number and kinds of periodic bisque kilns and glost kilns; number of car tunnel bisque and glost kilns; hours kilns are on fire and the cones reached in each of the various types of whiteware.

Ceramic Ranking of West Virginia

Most of the usual types of whiteware are manufactured in West Virginia. In the manufacture of semivitreous tableware the state ranks second, fourth in vitrified hotel china, second in floor tile, third in standard electrical porcelain. In addition there are manufactured in West Virginia wall tile, sanitary ware, and high tension electrical insulators for which figures are not at hand to show the state's ranking.

Materials Used

Clays In all whiteware production, a compounded body is used, this consisting in all West Virginia potteries of china clay, ball clay, flint, and feldspar as basic constituents. Of the 24 potteries in the state manufacturing whiteware, 21 use English china clays and 13 use domestic china clays; 18 use English ball clays and 13 use domestic ball clays. Seven plants use English clays exclusively and two use domestic clays exclusively. All of the seven plants manufacturing semivitreous dinner ware use English china and ball clays, but only one uses English china clays exclusively and none English ball clays exclusively. The potteries producing other types of ware cannot be easily classified in regard to the kinds of clays used, except that one plant manufacturing standard electrical porcelain and another manufacturing floor and wall tile, use domestic clays exclusively. Only one company reported using imported clay other than English clays. This is a tile plant using German "Halle" clay.

Feldspar Maine feldspar is used by half of the potteries; North Carolina and Tennessee feldspars rank next in order with one

[1] Presented at the Annual Meeting, American Ceramic Society, Toronto, Ont., February, 1930. (White Wares Division.) Received December 28, 1929.

pottery each using Canadian and Dakota feldspar, respectively. Feldspar is the most variable of all body materials, but in late years manufacturers have not experienced much difficulty in obtaining reasonably uniform feldspar from shipment to shipment. The feldspars used contain from 9 to a little over 12% K_2O and 0.9 to 2.8% Na_2O.

Flint West Virginia flint from Berkeley Springs is used by 16 of the 24 potteries, with no information from two potteries. Those manufacturing semivitreous ware use Berkeley Springs flint less than any other class, four of the seven using flints from other sources, namely Pennsylvania, Illinois, and Ohio. One plant producing electrical porcelain uses a Tennessee flint and one producing sanitary ware uses Illinois flint in addition to Berkeley Springs flint. As a rule, potteries have little difficulty in obtaining good grades of flint.

Cornwall Stone Cornwall stone, commonly used in England as a flux is used less commonly in this country. Two potteries in the state reported using Cornwall stone, one producing floor and wall tile and one standard electrical porcelain. Another pottery manufacturing floor and wall tile had used it until recently but discontinued its use.

Lawns Metal lawns usually of bronze far outnumber silk ones. The meshes in all cases reported vary from 100 to 200 meshes per inch. Potteries manufacturing semivitreous ware use lawns ranging from 120- to 140-mesh. Those producing vitrified hotel china use lawns 140- to 180-mesh for the first stage and 160- to 200-mesh for the second stage. Those producing standard electrical porcelain use lawns ranging from 110- to 140-mesh, and those producing sanitary ware use 100- to 140-mesh for the first stage and 140- to 200-mesh for the second stage.

Glazes Information about glazes was obtained from but 14 of the 24 potteries. All the plants manufacturing standard electrical porcelain and high tension electrical insulators use raw glazes. One plant manufacturing sanitary ware uses a raw glaze, all other plants use fritted glazes. Flint, feldspar, and china clay are used in the glazes by all potteries.

Whiting is used by all potteries except one; the same is true of zinc oxide. Boric acid is used by all potteries employing a fritted glaze, the acid in all cases being put in the frit only. The use of borax is not quite as universal; it is generally put in the frit, but one sanitary ware plant uses it in both the frit and the mill addition and another in a raw glaze. White lead is used in all fritted glazes, being put in some cases in both the frit and in the mill addition; it is also used in raw glazes. Tin oxide is used by two potteries, one using it in a raw glaze, another in the mill addition of a fritted glaze. Albany slip clay is used in one raw glaze and in the mill addition of one fritted glaze.

Firing In semivitreous porcelain manufacture, one pottery fires the bisque to cone 8, one to $8^1/_2$, four to cone 9 and one to $9^1/_2$. The periodic bisque kilns are on fire from 45 to 50 hours. In tunnel kilns the bisque ware is in the kiln from 68 to 86 hours, but this will vary considerably according to business conditions. Two potteries fire the glost ware to cone 4 and one each to cones 5, 6, and 7. Periodic glost kilns are on fire from 27 to 36 hours. In tunnel kilns the glost ware is in the kiln from 29 to 37 hours.

Decorations are fired to cones 017 to 010, no two potteries reporting the same cones. The periodic decorative kilns are 8 to 9 hours on fire; in tunnel kilns the ware is in the kiln 9 hours.

Vitrified hotel ware is all fired to cone 11 in the bisque. All the ware is fired in periodic kilns which are 56 to 70 hours on fire. The glost is fired to cone 6 in one pottery; in all potteries the glost kilns are on fire for 36 hours.

Three potteries manufacturing floor and wall tile fire the bisque to cones 11, $11^1/_2$, and 12, respectively, the kilns being on fire from 50 to 100 hours. The glost firing ranges from cones 1 to 7.

Standard electrical porcelain is all one fire ware. The ware is all fired to cone $10^1/_2$ or 11. The periodic kilns are on fire 42 to 50 hours.

Sanitary ware bisque is fired to cone 9 or $9^1/_2$. The periodic kilns are on fire for periods ranging from 40 to 60 hours. The glost is fired from cones 6 to 8, the kilns being on fire 40 to 60 hours.

Kilns There are 90 periodic downdraft bisque kilns in the state, ranging in diameters from 7 ft. 8 in. to 18 ft. 6 in. The kiln 16 ft. 6 in. in diameter is most common. Of these 90 kilns, 47 are used for firing semivitreous porcelain, 19 for sanitary ware, 12 for vitrified hotel china, 8 for standard electrical porcelain, 3 for floor and wall tile, and one for art pottery. In addition there are 43 downdraft or up- and down-draft periodic bisque kilns, one 16-chamber compartment kiln (for firing sanitary ware) and 10 bisque car tunnel kilns.

Of the 10 tunnel kilns for bisque firing, 7 are used for firing semivitreous dinner ware; these are all open-fire kilns. These kilns range in length from 203 to 377 feet. Three kilns are used for firing one-fire electrical porcelain. One of these is an open-fire kiln 321 feet long, two are muffle kilns 352 and 354 feet long, respectively.

For glost firing there are 69 downdraft periodic kilns, 12 downdraft or up- and down-draft kilns, and eight car tunnel kilns.

Of the eight tunnel glost kilns six are used for firing semivitreous dinner glost; these are open-fire kilns ranging in length from 165 to 308 feet. A combination muffle and open fire kiln 200 feet long is used for firing wall and mantle glost. One muffle kiln 273 feet long is used for firing wall tile glost.

The six decorative car tunnel kilns are all used for firing semivitreous dinner ware decorations. One of these is 143 feet long, and the others are 157 feet long.

DEPARTMENT OF CHEMICAL ENGINEERING
WEST VIRGINIA UNIVERSITY
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ACTIVITIES OF THE SOCIETY

AMERICAN CERAMIC SOCIETY HEADQUARTERS

It would be strange if you did not know your business headquarters. Yet this is exactly the status with most of the members regarding this, their own business, the AMERICAN CERAMIC SOCIETY. It is yours. It belongs to no one else. You should know where, how, and of what it is.

In the first place, its location is 2525 North High St., Columbus, Ohio, on the second floor, south side of the building, shown in Fig. 1. Your offices occupy one-half of the second floor.

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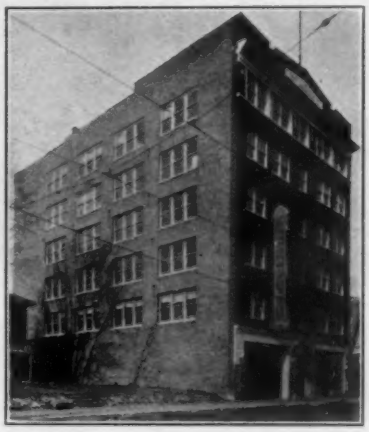

FIG. 1.—The Gus Pallous Building, 2525 N. High St., Columbus, Ohio.

Here is complete office equipment: multigraph, mimeograph, letter folder, envelope sealer, stamping machine, adding machine, typewriters, etc.

Note the book stacks containing back numbers of the *Transactions* and *Journals*, the bibliographies, and other literature for sale.

And Oh Boy! see that embryonic exhibit of ceramic ware, some for sheer beauty, some as examples of ceramic treatment in clay, glass, and vitreous enameled ware. This is not a collection of antiques, although antiques are displayed.

The office equipment represents considerable money investment but is on the books for a trifle more than $2000.00. Note the card and the stencil files; 10,000 stencils. With the multigraph, addressing machine, folder, sealer, stamper, and stock of steel signature cuts it is no trick to get out 1000 copies of a one-page letter in a day.

Turn facing the front. You will see the two front offices, some more exhibits and photographs. Turn again and walk past the stock bins, some of which are used for the exhibits. Figures 8 to 13 inclusive show this part of the office.

Walk on through the rear (as shown in Fig. 14) and out through the door you will find a large receiving and storage room.

At the extreme left rear of the main office is a door (shown in Fig. 2) that leads to the ladies' rest rooms and to the "cut file." Here are kept all the cuts of illustrations used in the *Transactions* and *Journals*.

Returning from the rear you will pass on your right the door into the office where the *Abstracts* are checked and edited. (See Figure 19.)

The books in the editorial offices constitute a nucleus of a ceramic library. It is slowly growing. The shelves now are overflowing and the desks fairly well stocked, but more books are being obtained constantly. Some day, when you can afford a librarian you will find here a rich storehouse of information at your command. The SOCIETY will take care of library donations.

Manufacturing firms are requested to add to this ceramic museum. Ware tracing

the changes and development in product and in processes as well as examples of present time products will be gladly received and properly displayed.

Now that you have seen your place of business by means of the camera, suppose you do two things: (1) come and see and use this office, and (2) help make it more completely a ceramic headquarters, museum, and library. This much has been assembled without concerted effort. It is only a beginning. It takes no great imagination to vision what you could make of your place of business if each and every member of the SOCIETY would contribute.

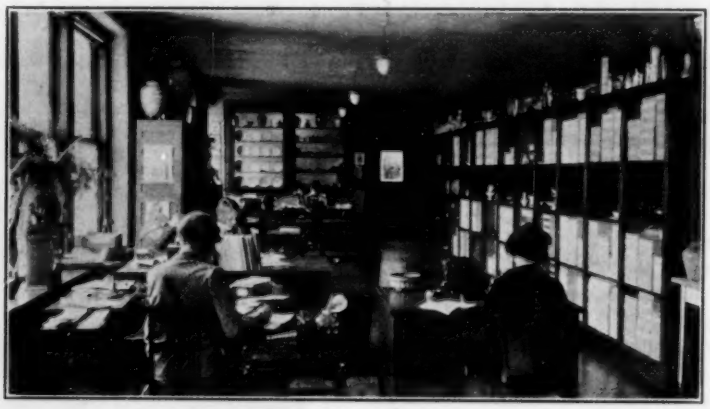

FIG. 2.—The main office looking west toward the rear. Note the S. A. Weller pottery on the file cabinet to the left.

FIG. 3.—The main office looking east.

FIG. 4.—Just to the left of the entrance with a peek into the office of the General Secretary. (1) Flint Faience Tile panel. (2) Abrasive Co. panel of abrasive products. (3) Northwestern Terra Cotta Co. vase. (4) Sparta Ceramic Co. tile boards. (5) Pooto of the SOCIETY's first Secretary, Gen. Edward Orton, Jr. He served 19 years.

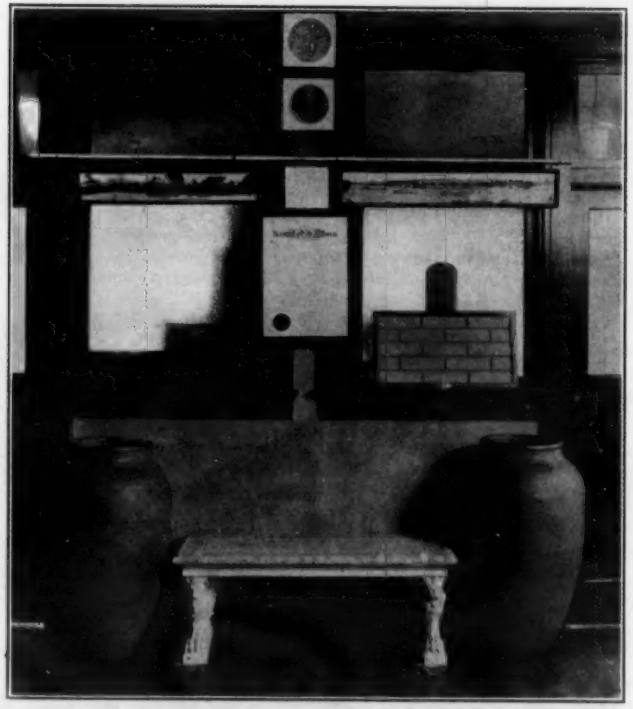

FIG. 5.—Between the front Editorial offices: (1) The SOCIETY Incorporation Charter and Seal. (2) The 103-inch Champion Porcelain Co. pyrometer tube. (3) The Northwestern Terra Cotta Co. garden seat. (4) The two jars by Maurice Knight. (5) Claycraft Mining and Brick Co. panel.

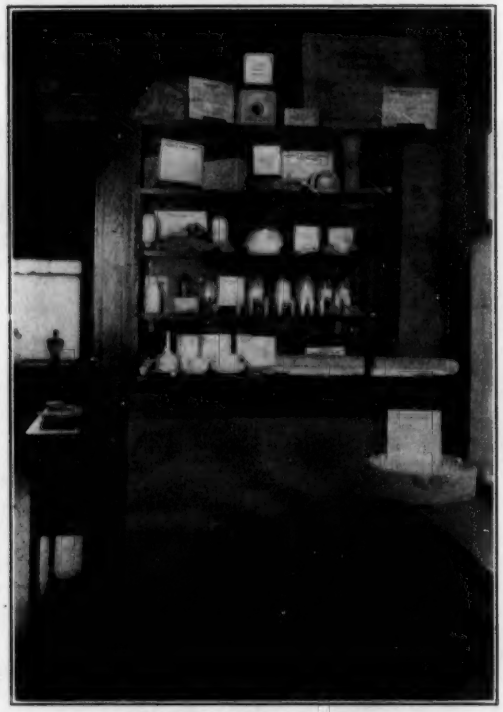

FIG. 6.—The Champion Porcelain Co. sillimanite spark plugs, chemical porcelain, and refractories.

FIG. 7.—Looking back at the entrance door from the Champion Porcelain corner: (1) The all-over enameled kitchen table by the Porcelain Enamel & Mfg. Co. (2) Wedgwood pottery on the table; also a vase by Margaret Cable, University of North Dakota. (3) Above center, Westinghouse high tension insulators. (4) Glass blower's tools. (5) Alliance Clay Product Co. brick panels. (6) Robertson Art Tile Co. boards on wall. (7) Sparta Ceramic Co. tile boards. (8) Charles Taylor Sons Co. high alumina brick. (9) Ava Brick Co. panel. (10) Stone Creek Brick Co. panels. (11) Finzer Bros. Clay Co. brick panel.

FIG. 8.—The east end of the *Journal* bins: (1) The large black vase on top was brought from Egypt by Col. Kilbourne (see also in Fig. 7). (2) In the first bin at front is an early Rookwood in white and blue underglaze marked 1888, 95, M. K. (3) In the second bin is a Lenox, Inc., exhibit.

FIG. 9.—The third and fourth bins: (1) Fostoria Glass Co. exhibit in third bin. (2) Guy Cowan Pottery exhibit in fourth bin.

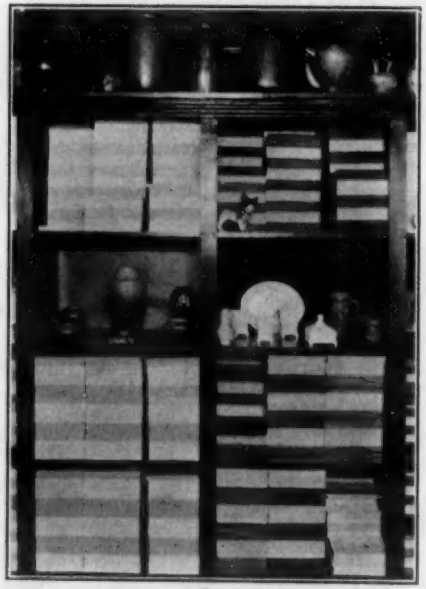

FIG. 10.—The fifth and sixth bins: (1) Examples of opalite glass in fifth bin. (2) Exhibit of vases made by students at Iowa State College, Ames, in sixth bin. (3) Above, third vase from right is by Prof. Arthur Baggs.

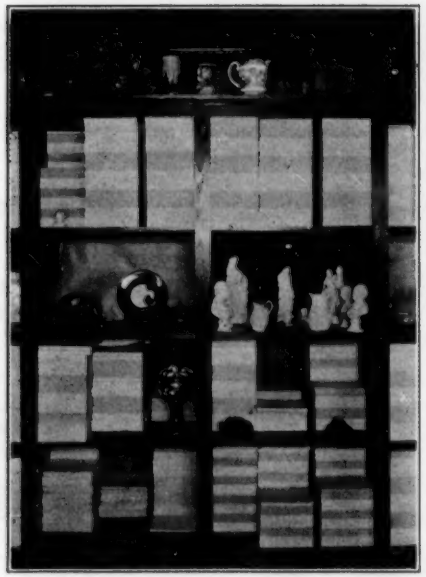

FIG. 11.—The seventh and eight bins: (1) In the seventh bin are Parian statues, busts, and pitchers. (2) The eighth bin is an assortment of black pieces. The plate by Onondaga Pottery Co., the elephant by Frederick H. Rhead, and the vase by Wedgwood.

FIG. 12.—The ninth and tenth bins: (1) In the ninth are two plates, a cup, and a saucer from Coxon Belleek China Co., Wooster, Ohio. (2) In the tenth are Wedgwood plates, each depicting a different scene on Harvard University Campus.

FIG. 13.—The eleventh and twelfth bins: (1) Upper eleventh bin exhibit is Weller Sacardi luster ware. (2) The second shelf of eleventh bin is exhibit of Onondaga china. (3) Upper twelfth bin is Homer Laughlin China Co. exhibit. (4) The second shelf of twelfth bin is Morgan Belleek china. (5) The third shelf twelfth bin is Cambridge Glass Co. exhibit.

FIG. 14.—At the rear of main office looking through the door into the receiving and storage room. At the left is a corner of the partition wall of the *Abstract* editorial office.

FIG. 15.—At rear of main office. The opaque windows behind the exhibit are the east partition of the *Abstract* office. (1) Mayer china at the left. (2) Hall china at the right. (3) Two vases at top are from Steuben Division, Corning Glass Works, by Fred Carder.

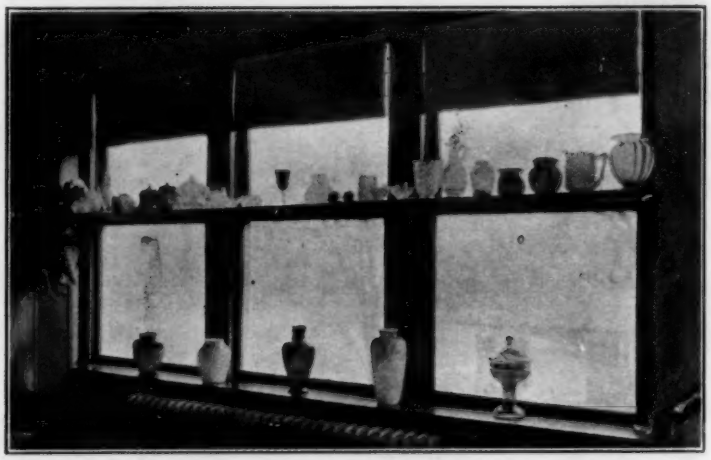

FIG. 16.—Viewing our glass exhibit looking southeast from rear of the main office. Three of Fred Carder's vases are shown on the window sill.

FIG. 17.—Looking into editorial office from east (front) of main office.

FIG. 18.—The editorial office looking west out into the main office.

FIG. 19.—A peep into the *Abstract* office located at rear of main office.

FIG. 20.—Office of General Secretary and Editor looking from the main office.

FIG. 21.—Looking from front of General Secretary's office out into the main office. At the extreme left a door opens into the Assistant Editor's office and way through to the rear of the main office is the glass window partition of the *Abstract* office. The Grecian vase at the left of the door is by Frederick H. Rhead. We have two of these, both with crystalline glaze.

FIG. 22.—Over the Secretary's desk. Photos of all charter members, past presidents, secretaries, and treasurers.

PROPOSED AMENDMENTS TO THE CONSTITUTION OF THE AMERICAN CERAMIC SOCIETY[1]

Submitted to the Society at the Toronto Meeting

Amend Article II, Section 1, to read as follows:

Article II

(1) The SOCIETY shall consist of Honorary Members, Ex officio Honorary Members, Fellows, Active Members, Life Members, Associate Members, Corporation Members, Life Corporation Members, and Industrial Association Members.

Amend Article II, by insertion between Section 4 and Section 5, the two following new Sections and renumbering the succeeding Sections in accordance therewith.

[1] See "Constitution and By-Laws of the AMERICAN CERAMIC SOCIETY," *Bull. Amer. Ceram. Soc.*, **8** [4], 71–81 (1929).

(5) Fellows shall compose a group of Active Members upon whom this title is conferred in recognition of their contributions to Ceramic Arts and Science. Active Members to be eligible to be elected Fellows must have been enrolled as Active Members not less than five years, and must have won recognition in the SOCIETY by high professional ideals, sustained interest in and devotion to the objects of the SOCIETY, broad and productive scholarship in Ceramic Science, or outstanding achievement in some branch of the Ceramic Arts. The methods to be used in determining the eligibility of a candidate shall be devised and administered by the Fellows.

(6) Fellows shall be nominated by at least seven Active Members in the Division in which their major interest lies. Upon nomination the candidate's name, his qualifications, and the list of his publications and achievements in the Ceramic Arts shall be submitted to a Jury of nine Fellows, to be known as the Fellowship Jury, which shall pass upon the nomination, and if they approve it by a vote of not less than seven affirmative votes, it shall then be certified to the Board of Trustees. If the Fellowship Jury shall fail to approve the nomination by the required vote, the candidate shall be so notified with a statement of the reasons for the action, but nothing in this action shall prevent a renewal of the nomination upon the lapse of not less than one year, in which case it shall be considered again as in the first instance. Any nomination which has been certified by the Fellowship Jury shall be considered by the Board of Trustees and if approved by a vote of not less than four-fifths of the Board, then the nominee shall be declared elected, and shall be publicly inducted into the Fellowship grade at the next convenient occasion, without ballot by the SOCIETY, and shall be presented with a suitable certificate of election by the SOCIETY. Persons elected Fellows shall be entitled to use the initials F.A.C.S. after their names, as a symbol of Fellowship, if they so desire.

Amend Article II, Sections 11 and 12, to read as follows:

(13) All Honorary Members, Ex officio Honorary Members, Fellows, Active Members, Life Members, Associate Members, Corporation Members, Life Corporation Members, and Industrial Association Members, shall be equally entitled to the privileges of membership, except that only Fellows, Active Members, Life Members, one representative of each Corporation Member, and one representative of each Life Corporation Member shall be entitled to vote. Such representative shall be officially designated by the person, firm or corporation represented. Only Fellows, Active Members, and Life Members shall be entitled to hold office. The Roster of each grade of membership shall be printed separately in at least one publication issued by the SOCIETY annually.

(14) Any person may be expelled from any grade of membership of the SOCIETY if written charges, signed by five or more Fellows, Active Members or Life Members be filed against him or her, and if said charges are considered and acted upon as set forth in Article VII, Section 4. In case of such expulsion, any moneys paid the SOCIETY as endowment fees become forfeit to the SOCIETY and automatically become a part of the Research Fund.

Amend Article III, by insertion between Section 1 and Section 2, the following new Section, to be marked Section 2, and change the number of succeeding paragraphs accordingly.

(2) The Annual Dues for Fellows shall be fixed by the Board of Trustees but shall not exceed seventeen and one-half dollars, six of which shall be a subscription to the *Journal of the American Ceramic Society*.

(3) The annual dues for Active and Associate Members shall be fixed by the Board of Trustees but shall not exceed twelve and one-half dollars, six of which shall be a subscription to the *Journal of the American Ceramic Society*.

Insert, following VI, the following new Article, to be designated Article VII, and renumber succeeding articles in accordance therewith.

Article VII
Fellows

(1) The grade of Fellowship, being conferred upon Active Members as a distinction in recognition of meritorious service and comprising members from all Divisions, shall not in itself confer upon its recipients any powers, rights, or duties different from those common to Active Members or Life Members, except as set forth hereinafter.

(2) The Fellows shall be charged with the consideration of all legislation emanating from Committees, which have a bearing upon the general policies of the SOCIETY outside of the special field of the Committee proposing the legislation, or recommendations from Divisions which have a bearing upon the activities of other Divisions than the one proposing the recommendation. Upon such legislation or recommendation being offered, it shall be referred by the President to the Fellows for their consideration, and upon return of such legislation or recommendation with their approval, then the Board of Trustees shall pass upon such legislation or recommendation by the vote of the majority. In event of the return of such legislation or recommendation with the disapproval of the Fellows, then the Board of Trustees shall not pass the same, except upon the affirmative vote of not less than four-fifths of the members of the Board.

(3) The Fellows shall be especially charged with the consideration of all questions of professional ethics and the formulation from time to time of Codes of Ethics for Ceramic Engineers, and others dealing with the subject matter of Ceramics in a professional capacity.

(4) In event of the filing of written charges against any member of the SOCIETY, as provided in Article II, Section 14, the matter shall be dealt with by a Committee of Fellows appointed by the Fellows for such purpose. Such person, however, shall be notified of the charges and of the date at which said charges will be considered, and given a reasonable time to appear before the Committee, either in person, or by counsel or both, or to present a written defense. The Committee shall then file a written report of its findings and its recommendation thereon with the Board of Trustees. The Board of Trustees may accept the recommendation of the Committee by majority vote, or may disapprove such recommendation by negative vote of not less than four-fifths of the Board. The decision of the Board shall be final.

(5) The Fellows shall have the right and the duty to consider from time to time any matter of general policy affecting the professional aspects of the work of the SOCIETY or of its relations to other professional societies, and to initiate such legislation relating thereto as it shall deem proper or necessary. Any such recommendations or legislation shall be referred to the Board of Trustees for action. The Board of Trustees may approve such action by majority vote or may disapprove such action by a four-fifths vote, or upon request of one or more of the Divisions, the Board shall publish the proposed action and place the final adoption of the same upon the affirmative vote of the majority of the SOCIETY present at an Annual Meeting or upon a two-thirds affirmative vote of those voting by letter ballot at the next annual election.

(6) The Board of Trustees may at any time refer to the Fellows any matter upon which they desire their opinion.

(7) The affairs of the Fellows shall be managed by a Chairman, a Secretary-Treasurer, and such other officers as they deem necessary. The officers shall be elected annually by ballot at the last session of the Fellows held during an Annual Meeting of the SOCIETY and shall take office at the close of the meeting at which they are elected. The officers shall hold office for one year or until their successors are elected.

(8) There shall be held one or more meetings of the Fellows at each Annual Meeting of the SOCIETY, at such time and place as may be agreed upon, and the Secretary of the SOCIETY shall make provision for such meetings and place them upon the printed pro-

gram of the Annual Meeting of the SOCIETY. The Fellows may hold such other meetings as they deem necessary for their work. The Fellows, as such, shall not have representatives upon the Divisions or upon the standing Committees of the SOCIETY.

(9) The Fellows shall have power to make their own rules and by-laws for the conduct of their business as they deem proper, except that they shall not adopt any rule or by-law which conflicts with the Constitution and By-Laws of the SOCIETY as a whole.

(10) The Board of Trustees shall make provision for the necessary expenses of the Fellows from the general funds of the SOCIETY.

Amend Section III of the By-Laws to read as follows:

Section III. Only Fellows and Active Members shall be eligible to election as officers.

Amend Section IV of the By-Laws to read as follows:

Section IV. Any members in arrears for over one year may be suspended from membership by the Board of Trustees until such arrears are paid. Fellows and Active Members in arrears are not eligible to vote. The Annual Dues are payable on January first.

Amend Section V of the By-Laws to read as follows:

Section V. The Secretary of the Fellows, and of each Division, Local Section, and Student Branch shall report to the Secretary of the SOCIETY the names of its officers, and Chairmen of its Committees, within three weeks of their election or appointment, and shall also furnish the Secretary with a complete list of its membership on April first of each year.

NEW MEMBERS RECEIVED FROM JANUARY 1 TO FEBRUARY 1

CORPORATION

Elm Works, Limited, Guy Campbell (voter), Summerstown, Tooting, London, S. W. 17, England.

Decal Products Co., Alfred Duhrssen (voter), East Liverpool, Ohio.

PERSONAL

Mircea Bucov, Direktor der AEG Porzellanfabrik Hennigsdorf, Betriebsführung Rosenthal, Hennigsdorf bei Berlin, Germany.

William Nelson Butterworth, 21 Division St., Mount Union, Pa.; Ceramic Engineer, Harbison-Walker Refractories Co.

A. H. Cole, 17540 Madison Ave., Lakewood, Ohio; Sales Engineer, M. A. Hanna Co.

Bernardo Elosua, Morelos Ote. 539, P. O. Box 360, Monterrey, N. L., Mexico; General Manager, Ladrillera Monterrey, S. A.

Ralph L. Evans, 72 Fifth Ave., New York, N. Y.; Secretary-Treasurer and Chemist, Luminique, Inc.

J. Otis Everhart, Ohio State Univ. Engineering Experiment Station, Roseville, Ohio.

Henry A. Frank, 4322 Van Buren Place, Los Angeles, Calif.; Assistant Chemist, Eljer-California Co.

Glenroy G. Grogan, 1366 Prairie Ave., Des Plaines, Ill.; Salesman, Vitro Mfg. Co., Chicago District Representative.

Henry Hall, Trentham, Tatnam Rd., Poole, Dorset, England; Works Manager, Carter & Co.

Minot K. Holmes, 112 S. Proud St., Muncie, Ind.; Chief Engineer, Hemingray Glass Co.

Vernon Linnaeus Mattson, 2 Washington St. South, Charleston, W. Va.; Mining Engineer, Norris & Tower Co.

Lawrence Alfred Palmer, 2630 Garfield St. N. W., Washington, D. C.; Research Associate, American Face Brick Assn.

Laurence E. Power, 494 Reed St., Milwaukee, Wis.; Chief Chemist, Allen-Bradley Co.

C. C. Rhodes, 5660 W. Taylor St., Chicago, Ill.; Edison Electric Appliance Co.
Hans Schlegelmilch, Keramag, Wesel, Germany.
L. L. Stephenson, Jr., 4104 Clairmont Ave., Birmingham, Ala.; Vice-President, Stephenson Brick Co.
Ralph H. Weston, Slidell, La.; Superintendent, Standard Clay Products Co.
Clyde E. Williams, Battelle Memorial Institute, 505 King Ave., Columbus, Ohio.
E. O. Wilson, Yenching University, Dept. of Chemistry, Peiping, China.
Walter H. Wolf, 840 N. Franklin St., Pottstown, Pa.; Ceramic Engineer, Porcelain Enamel & Mfg. Co.

STUDENT

N. Y. State School of Clayworking and Ceramics, Alfred, N. Y.

Robert Bassett **Robert Karl Smith**

Iowa State College, Ames, Iowa

Frank B. Hodgdon **Bernard C. Peters**

University of Illinois, Urbana, Ill.

Frederick Rognald Matson, Jr.

Membership Workers' Record

PERSONAL		CORPORATION	
R. A. Heindl	1	Frederick H. Rhead	1
A. R. Heubach	1	Office	1
W. V. Knowles	1		–
F. A. McCann	1	Total	2
J. A. Oravec	1	STUDENT	
C. W. Parmelee	1	C. R. Amberg	2
W. F. Steger	1	Paul E. Cox	1
A. S. Watts	1	R. K. Hursh	1
H. G. Wolfram	1	D. A. Moulton	1
Office	11		–
	—	Total	5
Total	20	Grand Total	27

MEMBERSHIP WORKERS' RECORD FOR THE YEAR 1929

For the past several years the annual record of persons who have obtained new members for the AMERICAN CERAMIC SOCIETY has been compiled from the record published each month in the *Bulletin*. A brief comparison of the membership work accomplished in 1929 with that of the years from 1924 to 1928 is an interesting study.

Year	Total Members	Year	Total Members
1924	268	1927	261
1925	215	1928	240
1926	243	1929	239

Judging from these records 1927 was the best year of the last three. Oddly enough 1924 was the best year, a record of 268 with 1927 second with a total of 261 members.

In the last three years we have had a steady decline in the number of persons working to obtain new members, the figures running 122, 117, and 95, the latter figure ending the year 1929.

For the ninety-five members who brought in one or more new members we have much praise. We have often stated that we are not anxious to obtain members solely for the sake of adding names to our membership list or numbers to our total. In fact we dis-

courage memberships from those whose interests are foreign to our work. But there are many persons in this country and abroad, whose chief interests center in ceramics, who need the friendship and stimulation found in our meetings and publications. Many of them do not know the routine of joining our organization and are waiting only for a suggestion.

Our Membership Committee chairmen need to wake up. Only seven new members were credited last year to the Membership Committee of the SOCIETY (which consists of seven Division representatives and a Chairman). The majority of membership work, therefore, has been done by members at large, whose interest in our work is active enough to urge them to invite their co-workers into our fellowship.

Let us encourage the ninety-five workers who secured our 1929 members, and get busy ourselves.

CORPORATION	
F. A. McCann	1
N. Stein	1
H. G. Thomson	1
W. W. Weigel	1
A. E. R. Westman	1
Office	10
Total	15

PERSONAL	
M. G. Ammon	1
A. I. Andrews	1
A. A. Ayars	1
C. E. Bales	2
L. E. Barringer	1
Henry N. Baumann, Jr.	1
Marion W. Blair	1
A. V. Bleininger	1
George Blumenthal, Jr.	1
Robert C. Boyd	1
J. E. Brinckerhoff	1
G. H. Brown	2
J. L. Carruthers	1
W. M. Cohn	1
H. T. Coss	1
Paul E. Cox	1
J. L. Crawford	2
J. W. Cruikshank	1
E. deF. Curtis	1
H. B. DuBois	2
R. F. Ferguson	1
F. C. Flint	1
Leon J. Frost	3
Charles F. Geiger	1
H. F. Goodwin	1
D. Hagar	1
J. E. Hansen	1
W. N. Harrison	1
F. M. Hartford	1
Fred A. Harvey	1
R. A. Heindl	1
A. R. Heubach	1
Philip Heuisler	1
Frank E. Hodek, Jr.	1
J. W. Hoehl	1
Gordon C. Keith	2
F. P. Knight, Jr.	1
Wm. V. Knowles	1

PERSONAL (*continued*)	
Raymond B. Ladoo	1
R. D. Landrum	2
S. B. Larkins	2
C. C. Leigh	2
A. E. MacGee	1
A. Malinovszky	2
W. D. Mavor	2
Sidney McCann	1
J. S. McDowell	2
R. J. Montgomery	1
W. F. Mooney	1
Bernard Moore	1
J. J. Moroney	1
Henry Oesterle	1
C. C. Pan	1
Gordon R. Pole	1
R. E. Polk	1
C. Presswood	1
Fred H. Robertson	1
R. D. Rudd	2
M. R. Scott	1
G. R. Shelton	1
G. Simcoe	1
A. L. Simison	1
R. E. Stark	2
H. R. Straight	1
K. B. Strong	1
L. G. Tait	1
Dorothy A. Texter	2
C. Thompson	1
E. Ward Tillotson	1
L. J. Trostel	3
W. E. S. Turner	1
A. S. Watts	1
W. W. Wilkins	5
Hewitt Wilson	1
H. G. Wolfram	1
T. Yoshioka	1
Office	61
Total	159

STUDENT	
Charles R. Amberg	2
A. I. Andrews	4
A. E. Baggs	1
G. H. Brown	3
Warren F. Copp	8

STUDENT (*continued*)	
Paul E. Cox	2
W. F. Dietrich	1
C. M. Dodd	3
A. F. Greaves-Walker	1
F. T. Heath	1
M. E. Holmes	1
R. K. Hursh	3
John B. Lyon	1
S. Mathews	1

STUDENT (*concluded*)	
D. A. Moulton	8
Clyde L. Thompson	2
A. S. Watts	3
F. Westendick	2
Hewitt Wilson	4
Office	14
Total	65
Grand Total	239

ROSTER CHANGES IN JANUARY

CORPORATION*

Abrasive Co., R. A. Shaffer (voter), Tacony and Fraley Sts., Bridesburg, Philadelphia, Pa. (Louis L. Byers (voter))

Missouri Fire Brick Co., J. M. Dell (voter), Vandalia, Mo. (6100 Manchester Ave., St. Louis, Mo.)

Standard Pyrometric Cone Co., Edward Orton, Jr. (voter), 1445 Summit St., Columbus, Ohio. (1538 N. High St.)

PERSONAL*

Bouckley, Thomas, Canada Gypsum & Alabastine, Ltd., Caledonia, Ont., Canada (Paris, Ont., Canada)

Brockman, E. A., 526 E. 4th St., Lincoln Apts. No. 14, Cincinnati, Ohio. (Lincoln Apts. No. 18)

Brown, Lawrence H., P. O. Box 632, East Liverpool, Ohio. (Hall China Co.)

Burchfiel, B. M., Gladding, McBean & Co., 621 S. Hope St., Los Angeles, Calif. (P. O. Box 634, Avalon, Calif.)

Collings, William A., Box 937–7, Santa Monica, Calif. (Box 862)

Crowley, Henry L., Henry L. Crowley & Co., Inc., 1 Central Ave., West Orange, N. J. (545 N. Arlington Ave., East Orange, N. J.)

Dippell, Lawrence V., Park Towers Apt. No. 110, Kemble Ave., Philadelphia, Pa. (601 Union St., Jackson, Mich.)

Falter, Arthur H., 4956 McPherson Ave., St. Louis, Mo.; Laclede-Christy Clay Products Co. (2305 Summit St., Columbus, Ohio)

Fesler, Raymond T., 709½ E. Mulberry St., Kokomo, Ind. (222 E. Mulberry St.)

Giehler, F. J., Chicago Retort & Fire Brick Co., Ottawa, Ill. (Chicago, Ill.)

Gosser, George W., 550 Cambridge St., Coshocton, Ohio. (438 S. 4th St.)

Heath, Fred T., 1117 Bellevue Ave., Syracuse, N. Y. (Box 27, Station B, Columbus, Ohio)

Hemsteger, Samuel E., 48 St. Mark's Place, New Brighton, Staten Island, N. Y. (313 Aberdeen Drive, Middletown, Ohio)

Henderson, H. B., Standard Pyrometric Cone Co., 1445 Summit St., Columbus, Ohio. (1538 N. High St., Columbus, Ohio)

Houpt, Clayton S., 13945 Freeland Ave., Apt. 4, Detroit, Mich. (13279 Terry Ave.)

Hughes, Adrian C., Harbison-Walker Refractories Co., Clearfield No. 2 Works, Clearfield, Pa. (Mellon Institute, Pittsburgh, Pa.)

Leibson, J. S., Porcelain Dept., General Electric Co., Schenectady, N. Y. (Research Laboratory)

McCreery, George L., 618 Hopocan Ave. W., Barberton, Ohio. (220 Hopocan Ave. W.)

Mitra, Himansu K., 3610 Fifth Ave., Pittsburgh, Pa. (Engineering Expt. Station, Ohio State Univ., Columbus, Ohio)

Nayar, Mulkh Raj, Punjab National Bank, Ludhiana, India. (Benares Hindu Univ., Benares, India)

Ortman, F. B., Gladding, McBean & Co., 621 S. Hope St., Room 1300, Los Angeles, Calif. (Box 1480, Station C)

Parkhurst, Howard M., General Refractories Co., 742 Russ Bldg., San Francisco, Calif. (4138 Washington Blvd., Chicago, Ill.)

Petrie, Earl C., Cheswick, Pa.; Mellon Institute, Pittsburgh, Pa. (70 18th Ave., Columbus, Ohio)

* Addresses within the parentheses ( ) represent the old address.

Richard, Giulio, Via S. Vittore 40, Milano, Italy. (Via Antonio Beretta 8)
Robertson, Randal K., 320 Canada Cement Bldg., Montreal, Que., Canada. (1174 Phillips Place)
Rupp, Edwin M., 13 E. Maple, Mt. Healthy, Ohio. (Cambridge Wheatley Tile Co., Covington, Ky.)
Skalla, Charles N., 1739 Rivadavia, 9° Piso, Buenos Aires, Argentina. (Calle Zepita 2921)
Solon, L. V., Federal Seaboard Terra Cotta Co., 10 E. 40th St., New York, N. Y. (Magnolia Ave., Tenafly, N. J.)
Steinhoff, F. L., 407 S. Dearborn St., Chicago, Ill. (513 Forest Ave., Apt. 10, Glen Ellyn, Ill.)
Stephenson, H. H., Y. M. C. A., Auckland, New Zealand. (Post Office, Auckland, New Zealand)
Watters, Curtis R., 20 Linden Rd., Mansfield, Ohio. (General Delivery)

STUDENT*

Crisfield, A. P., 81 Peachtree Place, Atlanta, Ga. (P. O. Box 1313, Savannah, Ga.)
Morris, Kenneth, Room 21, Chemistry Bldg., Iowa State College, Ames, Iowa. (118 Hyland St.)

These roster changes, which are published each month, may be checked against the complete Membership Roster which was published in the July, 1929, issue of the *Bulletin*. Copies of this issue may be obtained from the Secretary's office, price $2.00.

* Addresses within the parentheses ( ) represent the old address.

NEWS FROM THE LOCAL SECTIONS

Pacific Northwest Section[1]

The 1930 annual meeting of the Pacific Northwest Section was held in Seattle on January 17 and 18. The technical session met during the afternoon of the 17th in the Mines-Ceramic Building on the University of Washington campus, with President E. E. Saunders presiding. The delegates were welcomed by Milnor Roberts, Dean of the College of Mines, and the following program was given:

(1) "Purification of Clays by Washing," Wurth Kriegel, University of Washington.
(2) "Practical Clay Products Research," by A. L. Miller, Executive Officer, Dept. of Civil Engineering, Univ. of Washington.
(3) "Cyanite in Southern Idaho," by G. L. Rogers, Engineer, Gladding, McBean and Co.
(4) "Geology of Eastern Washington with Reference to the Formation of Kaolin," by G. E. Goodspeed, Univ. of Washington.
(5) "A Method of Eliminating Auger Lamination," by Neal Fosseen, Washington Brick Lime and Sewer Pipe Co.
(6) "Preliminary Note on the Study of Refractories in Recovery Furnaces for Sodium Liquors in Pulp and Paper Plants," by J. A. Cunliffe, Univ. of Washington.
(7) "Saving Coal in Kiln Firing," by Howard Mansur, Engineer, Gladding, McBean and Co.
(8) "Dewatering Clay Suspensions by Electricity," by C. E. Curtis, Univ. of Washington.
(9) "The Wenatchee Fire Clays," L. A. Martin, Gladding, McBean and Co.

Dinner was served at the University Commons and the program finished around the table.

The sessions were continued at the Olympic Hotel in coöperation with the Pacific Northwest Brick and Tile Association, with their president, H. R. Kreitzer, presiding.

[1] Hewitt Wilson, *Secretary*.

(1) "Report of the Testing of Pacific Northwest Brick and Tile," by A. L. Miller, Univ. of Washington.
(2) "Design Requirements for Industrial Buildings," by W. R. Engstrom, Engineer for the Austin Company.
(3) "Design Requirements for Business Sub-Center Buildings," by R. C. Erskine, Seattle Real Estate Board.

The Annual Banquet in the Olympic Hotel's Marine dining room was a joyous celebration. Wylie Hemphill, newly elected president of the Seattle Chamber of Commerce gave the principal address of the evening and Lloyd Spencer, popular entertainer, lead the joking contingent.

The following officers were elected for the year 1930:

President, Alex H. Corbett, Granger Clay Products Co., Yakima, Wash.
Vice-President, P. L. Lingren, Gladding, McBean and Co., Portland
Secretary, Hewitt Wilson, Univ. of Washington
Treasurer, H. O. Thompson, Builders' Brick Co., Seattle
Trustee (Brick and Tile Division), W. J. Howard, Secretary, P. N. W. Brick and Tile Assn.
Trustee (Terra Cotta and Pottery), A. B. Fosseen, Washington Brick Lime and Sewer Pipe Co., Spokane
Trustee (Sewer Pipe), W. E. Lemley, Gladding, McBean and Co., Taylor, Wash.

The first year of research and testing work was admirably performed by A. L. Miller, and his reports formed the basis for the two days' program. Nineteen firms, representing practically all the brick and tile of the Pacific Northwest contributed $1000.00 for testing 66 batches of building brick, 27 batches of partition tile and 20 batches of load-bearing wall tile. These were tested under the A.S.T.M. specifications and the results indicate that the Northwest is producing an excellent grade of clay building products. The research program will be continued this year in the field of drain tile testing and a study of mortar materials.

Arrangements are being made for a summer meeting in Victoria, B. C.

Those in attendance were as follows: From *Gladding, McBean & Co.*, J. Geo. Adderson, S. R. Mercer, and Gene Faure (Renton, Wash.); E. Davies, T. E. Nicholson, and Olaf Olsen (Auburn, Wash.); J. S. Cole and E. E. Saunders (Spokane, Wash.); C. M. Brasfield, G. N. DeGolyer, Jr., S. Geijsbeek, A. N. Johnson, J. C. Johnston, Paul S. MacMichael, E. K. McQuarrie, Silas Rich, Gregory L. Rogers, and Raymond R. Smith (Seattle, Wash.); Howard Mansur (Taylor, Wash.); L. A. Martin (Wenatchee, Wash.). From *Seattle Brick and Tile Co.*, W. C. Hutchins, Frank Lohse, George R. Stirrat and John Stirrat (Seattle, Wash.). Robert Hidden, *Hidden Brick Co.* (Vancouver, Wash.). From *Builders' Brick Co.*, J. B. Campbell, R. Empens, Arthur Houlahan, Clifford Houlahan, Frank Houlahan, L. J. Leitch, and H. O. Thompson (Seattle, Wash.). O. K. Edwards, *Willamina Clay Products Co.* (Portland, Ore.). From *Washington Brick Lime and Sewer Pipe Co.*, A. B. Fosseen, Neal Fosseen, V. B. Kelsey, and H. P. Leipham (Spokane, Wash.). L. R. Harrison, *Albany Brick and Tile Co.* (Albany, Ore.). H. R. Kreitzer, *Columbia Brick Works* (Portland, Ore.). W. A. Luney, *Baker Brick and Tile Co.* (Victoria, B. C.). J. Parfitt, *Victoria Brick Co.* (Victoria, B. C.). Henry Hoffmann, *Lake Union Brick Co.* (Seattle, Wash.). From *University of Washington*, C. E. Curtis, J. A. Cunliffe, Harold Clem, J. Daniels, L. C. Eager, G. E. Goodspeed, Fred Kettenring, Jr., Wurth Kriegel, James Hammock, A. L. Miller, Milnor Roberts, W. J. Wathall, Frank McKinlay, and Hewitt Wilson. Alex H. Corbett, *Granger Clay Products Co.* (Yakima, Wash.). N. H. Nelson, *Pacific Coast Co.* (Seattle, Wash.).

BINNS' MEDAL AWARD

It has been announced that the Binns' Medal for 1929 has been awarded to Stanley G. Burt, Cincinnati, Ohio. Mr. Burt is a charter member of the AMERICAN CERAMIC SOCIETY.

NOTES AND NEWS

APPROPRIATION TO UNIVERSITY FOR STUDY OF TABLEWARE

The following letter was received in the offices of the AMERICAN CERAMIC SOCIETY a few days before the Annual Meeting of the SOCIETY in Toronto, Ont.

GENERAL EDUCATION BOARD

Founded by John D. Rockefeller, 1902
61 BROADWAY, NEW YORK

INDUSTRIAL ART
CHARLES E. RICHARDS, DIRECTOR

February 10, 1930.

Dear Mr. Purdy:

Thank you for sending me the copy of the program of the Toronto Meeting of the AMERICAN CERAMIC SOCIETY. I wish indeed that it were possible for me to attend this very interesting Meeting, but my engagements prevent my considering it.

I am glad to inform you that, at its meeting this morning, the Executive Committee of the General Education Board appropriated the sum of $8000 for a two-year grant of $4000 per annum, beginning July 1, 1930, to Ohio State University for the creation of a scholarship in ceramic design applied to tableware, together with provision for research as to technical and market requirements. I sincerely hope that the administration of this grant will be such as to win the respect and confidence of the ceramic industry and lead to its continued support of this or similar undertakings.

Very truly yours,
C. R. RICHARDS

Mr. Ross C. Purdy
AMERICAN CERAMIC SOCIETY
2525 N. High Street
Columbus, Ohio

CRR:JW

The appropriation was made as a direct result of the activities of E. de F. Curtis, Chairman of the Art Division, AMERICAN CERAMIC SOCIETY, and of Ross C. Purdy, General Secretary. The work will be in charge of Professor Arthur E. Baggs, of the Ceramic Art Department at Ohio State University, who is coöperating with the AMERICAN CERAMIC SOCIETY in the establishment of a research scholarship in ceramic art.

Definite plans for the work will be announced later but the general purpose of the study will be to improve the design and decoration of whiteware or tableware made by American manufacturers to enable them to assume much of the trade which now goes to European tableware manufacturers.

NEWS FROM THE CERAMIC SCHOOLS

Ohio State University[1]

Keramos, honorary ceramic engineering fraternity, held an initiation at Pomerene Hall, Thursday, February 13. This initiation was preceded by a dinner after which the following men were taken into the SOCIETY: Arthur Drake, Milton Waldschmidt, Stanley

[1] Glenn A. Hutt, *Corresponding Secretary.*

Leaver, and Walter Hayes. Honorary membership was also awarded to R. M. King, assistant professor of Ceramic Engineering at Ohio State University.

Ross C. Purdy, General Secretary of the AMERICAN CERAMIC SOCIETY, gave an illustrated address on "Manufactured Abrasives." In his introduction Mr. Purdy stated that Professor Acheson, in an attempt to manufacture synthetic diamonds made a discovery which advanced the manufacture of abrasives, and made it possible for the industry to reach its present high standard. A film was presented showing the many uses of abrasive materials. Mr. Purdy stressed the fact that a ceramic engineer dealing with abrasives must also be an organic chemist.

G. A. Bole, president of the AMERICAN CERAMIC SOCIETY and professor of Ceramic Engineering at Ohio State University and G. H. Brown, professor of Ceramic Engineering at Rutgers University, have been awarded honorary memberships. They were initiated at the thirty-second Annual Meeting of the AMERICAN CERAMIC SOCIETY at Toronto, Canada, by the following members: Karl Schwartzwalder, Gilbert Soler, Norman Wedemeyer, and Glenn Hutt, seniors, W. C. Rueckel and Emerson Emrich of the class of 1929, and Professor A. S. Watts of the ceramic engineering department.

Keramos Society Makes Study of Feldspars

Keramos, honorary ceramic engineering fraternity, is making a study of fifteen commercial brands of feldspars and their application in the ceramic industry.

Work will be carried on under the supervision of Arthur S. Watts of the ceramic engineering department. The seniors who will conduct the research are: Arthur D. Drake, Willard K. Carter, Glenn A. Hutt, Walter Rueckel, Karl Schwartzwalder, Edward Seabright, Gilbert Soler, Stephen Spires, Harry Thiemecke, George Tuttle. Norman Wedemeyer, and Thomas Faulkner.

Tests will be made to determine the value of feldspars in the manufacture of china, sanitary ware, electrical porcelain, floor and wall tile. Twelve of the most prominent ceramic manufacturers in the U.S. chose the 15 feldspars to be tested. These samples will also be analyzed and examined microscopically.

A preliminary report on the data collected was given at the Annual Meeting of the AMERICAN CERAMIC SOCIETY in Toronto, Canada, February 16–20. The results when completed will be published in the *Journal of the American Ceramic Society*. The complete data also will be used in a special bulletin to be issued by the Engineering Experiment Station.

Last year Walter C. Rueckel, president of Keramos, 1929, with the aid of the other members of Keramos, won a prize of $1000 for research work in the uses of kaolins in electrical porcelain bodies.

Student Branch Dance at American Ceramic Society Offices

The Student Branch of the AMERICAN CERAMIC SOCIETY held its first dance of the year at the offices of the AMERICAN CERAMIC SOCIETY in Columbus. Twenty-five couples were present and made this one of the best dances given by the Student Branch.

Mr. and Mrs. R. C. Purdy, Professor and Mrs. Arthur Baggs, Dr. and Mrs. G. A. Bole, and Professor and Mrs. J. L. Carruthers were the chaperones for the evening. Through the generosity of Mr. Purdy refreshments were served. Other dances for the students will be scheduled this spring.

Gilbert Soler, Engineering 4, president of the Ohio State Student Branch of the AMERICAN CERAMIC SOCIETY asked that a public speaking course be incorporated in the curriculum of ceramic engineers. If a consensus of opinion warrants the introduction of such a course, Dean Embury A. Hitchcock of the College of Engineering will favor its incorporation in the curriculum.

Missouri School of Mines and Metallurgy

(1) The second semester is now in operation with the enrolment in the Ceramic Engineering Department totaling 41, a 30% increase over last year's enrolment, and representing a growth from 3 to 41 in four years.

(2) The Missouri Refractories Association scholarship was awarded by the Faculty Committee on Scholarships to George A. Page, of Webb City, Mo. This award goes to Senior Ceramic Engineering students who have to their credit an all-round college record of outstanding distinction. In addition to making a scholarship record in the Ceramic Department of exceedingly high standard, Page has carried out two pieces of research work befitting a graduate of several years' experience, and he has taken extra work in the Chemical Engineering Department which will almost qualify him as a Chemical Engineer.

(3) The Ceramic Department research work is being concentrated on the dry-press process of making brick, and research work on various problems connected with the refractories industry. Reports were made at the National Brick Manufacturers Association convention, and the AMERICAN CERAMIC SOCIETY Annual Meeting.

(4) H. S. McQueen, Assistant State Geologist of Missouri, lectured to the Ceramic students on "Missouri Clays" on February 18 and 20.

(5) Nine Ceramic Engineering students are scheduled to graduate at the end of this semester.

(6) E. T. Harvey graduated in this department at the end of last semester and has left to take up his duties with The General Refractories Company.

(7) Plans are being made for the Inspection Trip of the Senior Ceramic students, who, this year, will journey to Ohio.

(8) The lecture course on "Lime, Gypsum, and Cement" is being given this semester for the first time. This is expected to develop into an important part of the ceramic curriculum.

New York State School of Clayworking and Ceramics[1]

Robert Sherwood, former Alfred graduate and now with Pass and Seymour, Inc., at Syracuse, in a talk before the Student Branch of the AMERICAN CERAMIC SOCIETY at their regular Tuesday meeting, Dec. 17, discussed the formation of an Alumni Association of graduates of the New York State School of Clayworking and Ceramics.

At a recent meeting of the New York Chapter of Beta Pi Kappa at Alfred, Professor Shaw, Director of the Ceramic School at Pennsylvania State College, was elected to honorary membership in this professional ceramic fraternity. He has accepted and is to be initiated at an early date.

Eugene Bryant, John Hillmiller, and Harry Sackett were elected to active member-

[1] E. H. Spencer.

ship in the New York Chapter of the Beta Pi Kappa fraternity at the regular meeting Dec. 11.

Professor C. R. Amberg of the Ceramic Engineering Department attended the conference of the Feldspar Grinders' Institute held in Washington, D. C., Jan. 15. The purpose of the meeting was to obtain a standard system of feldspar classification which when put in operation will materially assist users of feldspar in determining the proper feldspar for their individual requirements.

The following is a list of the seniors in the New York State School of Clayworking and Ceramics who have elected thesis work and the subjects chosen:

Robert Basset, "Thermal Expansion Furnace for Measurement of Refractory Materials."
Milton Burdick, "Colored Sanitary Ware Glazes."
Gerard Jacquiss, "Stickers in Floor Tile Firing."
Harold Karthouser, "Accelerators and Retarders in Cements."
Don Lynn, "Comparative Properties of Machine and Hand Mixed Plaster of Paris."
Jack McGraw, "Comparison of Soda and Potash Feldspars."
James Mays, "Carborundum Refractories."
Delos Wamsley, "Effects of the Size of Grain of Feldspar in Porcelain."

On Friday, Jan. 10, Charles M. Harder of the Ceramic Art School exhibited a collection of pottery which he has recently completed and which is to form a one-man exhibition to be held this month at the Potter's Shop in New York City.

OFFICERS OF FELDSPAR GRINDERS' INSTITUTE

At the first annual meeting of the Feldspar Grinders' Institute held on Friday, February 21, 1930, at the New York Athletic Club, the new officers were elected. They are as follows:

President, H. P. Margerum, Consolidated Feldspar Corp.
Vice-Presidents { C. H. Peddrick, Jr., United Feldspar Corp.; Herreld D. Thropp, Eureka Flint & Spar Co.; James Turner, Trenton Flint & Spar Co.
Secy.-Treas., L. L. Hunt, Bedford Mining Co.

The above with the following three men comprise the Directors of the Institute:

Richard Wainford, Trenton Flint & Spar Co.
Norman G. Smith, Maine Feldspar Co.
H. G. McLear, Green Hill Mining Co.

JOSIAH WEDGWOOD BICENTENARY

The detailed plans for the Wedgwood Bicentenary to be held at Stoke-on-Trent, England, May 18–23, 1930 are being completed and the following program has been compiled from letters from J. W. Mellor, chief host to the visiting American ceramists, and Thos. Cook & Sons. The latter company is in charge of the arrangements for the Americans who are planning to visit England for the purpose of attending the celebration.

On Sunday, May 18, arrangements have been made for a visit from the Archbishop of Canterbury.

Monday May 19 Her Royal Highness, Princess Mary, Countess of Harewood, will honor Stoke-on-Trent with a visit. She will be received by the Lord Mayor and will declare open the exhibition of modern pottery, and later will open the historical exhibition.

Tuesday May 20 (Transport Day) Sir Ralph Wedgwood, direct descendant of Josiah Wedgwood, who was a transport pioneer, will assist with the ceremonies for the day. Sir Ralph is general manager of the L. N. E. R. Sir Josiah Stamp, president of the L. M. S., and Major Frank Wedgwood, a director of the L. M. S., will be present.

Wednesday May 21 (Ceramic Day) The Ceramic organizations from the following countries will be present to participate in the celebration of Ceramic Day: United States, Canada, Belgium, Sweden, Denmark, Germany, Czechoslovakia, France, Italy, India, Japan, Holland, and Portugal. They will assemble at Town Hall, Stoke-on-Trent at 10 A.M., and a reception will be given to the English Ceramic Society and guests by the Lord Mayor and Lady Mayoress. The guests will then proceed to the Stoke Church Yard where each organization will place a wreath on Wedgwood's grave.

At 11:30 congratulatory addresses will be given from foreign ceramic societies. The AMERICAN CERAMIC SOCIETY will be represented by Karl Langenbeck, A. V. Bleininger, Edward Orton, Jr., Frederick H. Rhead, William E. Wells, R. H. Pass,[1] D. W. Scammell, B. E. Salisbury, and Geo. C. Thompson.

Luncheon will be served at 1 P.M., provided by the city of Stoke-on-Trent.

At 1 P.M. a reception will be held at Sandon Hall, by the Lord Lieutenant of the County, Earl of Harrowby. In the evening the official dinner of the English Ceramic Society will be held at the Town Hall. The prizes will be presented to the winner of the Essay Competition at this time.

Thursday May 22 The guests will assemble in the Council Chamber, Town Hall. An oration on Wedgwood will be given by R. L. Hobson, Department of Ceramics and Ethnography, British Museum, and brief remarks on Wedgwood will be made by several other speakers.

Wedgwood's Works in Etruria will be visited.

Provision for luncheon will be made by Major Wedgwood.

At 2:45 P.M. the Historical Pageant. Mrs. W. J. Gardner, wife of the president of the Ceramic Society will preside at the opening.

In the evening a dinner dance will be held at the National Federation of Clay Industries.

Friday May 23 The meetings of all of the sections of the Ceramic Society including the National Federation of Clay Industries at Town Hall, Burslem. The ladies will visit Minton's and Copeland's Works.

Business meetings of the different sections of the Ceramic Society will be held, and plant visits will be scheduled.

At 4 P.M. a popular lecture will be given by Karl Langenbeck, AMERICAN CERAMIC SOCIETY on "A Rare Open Mind and Civic Responsibility in Private Industry—England's Good Fortune in Staffordshire's Greatest Sons."

The city pageant, supper, and ball will be held in the evening.

Outline of Pageant

The pageant, which will be held daily at 2:45 P.M. from Monday, May 19 to Saturday, May 24, will be presented in eight episodes. Five thousand performers will take part

[1] An announcement of the subjects to be discussed by these men will be found in *Bull. Amer. Ceram. Soc.*, 9 [2], 46 (1930).

in this pageant and will be assisted by a chorus of five hundred voices and orchestra of 100 pieces.

The episodes will be given in the following order:

Introduction

(I) Early Britons urged by their Arch Druid to resist the occupation of the Romans under Suetonius Paulinus at Stoke-on-Trent, A.D. 58.

(II) St. Chad addressing British converts when the sons of Wulfhere were murdered at Stone, A.D. 650.

(III) John of Gaunt receives the Manorial dues, holds the Minstrels' Court, and presents the Wychnor Flitch, A.D. 1374.

(IV) The Dissolution of Hulton Abbey, and its surrender to the Commissioners of Henry VIII, A.D. 1539.

(V) Pioneer Peasant Potters, at work and play, A.D. 1630–1730.

(VI) Incidents in the Life and Time of Josiah Wedgwood, A.D. 1730–1795.

(VII) Thomas Cooper, and the Chartist movement at Hanley, A.D. 1842.

(VIII) Allegorical portrayal of the Modern Potteries' Industries.

Grand tableau and march past.

Trips in England Following Celebration

After the celebration at Stoke-on-Trent, an excursion about England is being arranged for those who desire it. The itinerary will probably include the following places: Stoke, Buxton, Sheffield, Leeds, Newcastle-on-Tyne, Glasgow, Manchester, Stourbridge, and London; or Cornish and Devon clays and London. These tours will be directed by Thos. Cook and Sons. Mr. Halliday, Secretary, National Federation of Clay Industries, Drayton House, 30, Gordon Street, London, W. C. 1, is acting as excursion secretary.

CALENDAR OF CONVENTIONS

Organization	Date	Place
American Assn. for the Advancement of Science	December 29, 1930 to January 3, 1931	Cleveland, Ohio
AMERICAN CERAMIC SOCIETY	February 22–27, 1931	Cleveland, Ohio
American Chemical Society	April 8–12, 1930	Atlanta, Ga.
American Electrochemical Society	May 29–31	St. Louis, Mo.
	September 25–27, 1930	Detroit, Mich.
American Foundrymen's Assn.	May 12–16, 1930	Cleveland, Ohio
American Gas Assn.	October 13–17, 1930	Atlantic City, N. J.
American Institute of Chemical Engineers	June 4–6, 1930	Detroit, Mich.
American Mining Congress		
Southern Division Meeting	March 10–12, 1930	Little Rock, Ark.
Annual Convention of Practical Coal Operating Men and National Exposition of Coal Mine Equipment	May 5–9, 1930	Cincinnati, Ohio
Western Division Meeting	October 13–18, 1930	El Paso, Texas
Annual Convention	December 1–6, 1930	Washington, D. C.
American Refractories Institute	May 19–20, 1930	White Sulphur Springs, W. Va.
American Society of Mechanical Engineers		
Fiftieth Anniversary Meeting	April 5–9, 1930	New York, N. Y., and Washington, D. C.

Semi-Annual Meeting	June 9–12, 1930	Detroit, Mich.
American Society for Steel Treating	September 22–27, 1930	Chicago, Ill.
American Society for Testing Materials	June 23–27, 1930	Atlantic City, N. J.
Assn. of Scientific Apparatus Makers of the U. S.	May, 1930	Atlantic City, N. J.
Grinding Wheel Mfrs. Assn.	March 7, 1930	Buffalo, N. Y.
National Academy of Sciences	April 28–30, 1930	Washington, D. C.
National Assn. of Manufacturers of Pressed and Blown Glassware	March 11, 1930	Pittsburgh, Pa.
National Electrical Exposition	October 6–11, 1930	New York, N. Y.
National Exposition of Power and Mechanical Engineering	December 1–6, 1930	New York, N. Y.
National Glass Distributors Assn.	December 2–4, 1930	Pittsburgh, Pa.
National Safety Council	September 29 to October 4, 1930	Pittsburgh, Pa.
New Jersey Clay Workers Assn.	June, 1930	Asbury Park, N. J.
Taylor Society	May 1 and 2, 1930	Columbus, Ohio
	December 3–5, 1930	New York, N. Y.
Tile and Mantel Contractors' Assn. of America	April 8–12, 1930	New Orleans, La.

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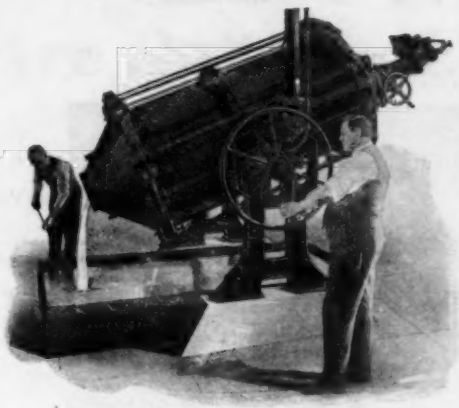

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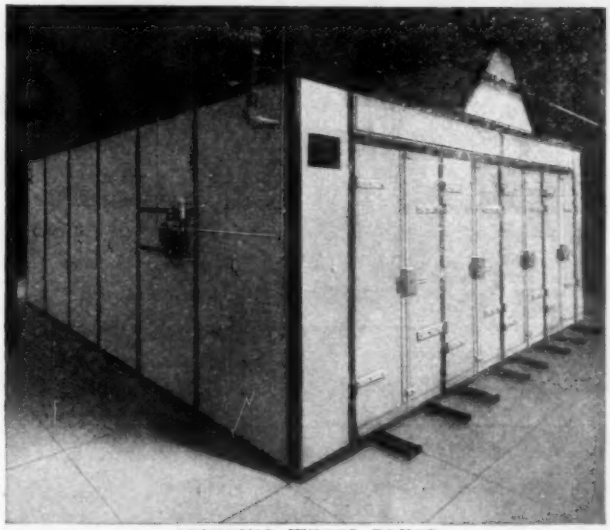

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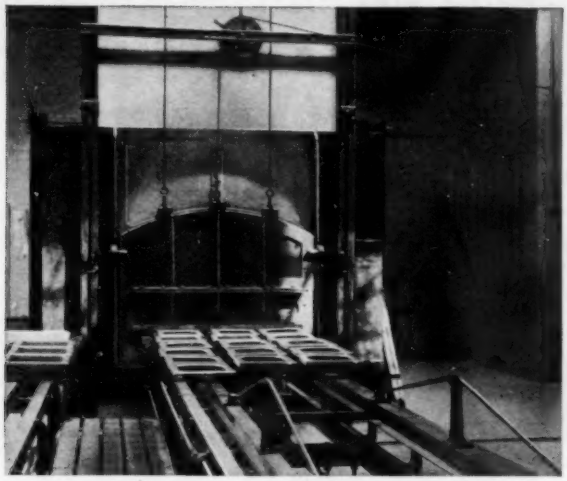

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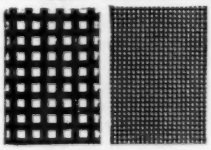
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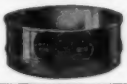
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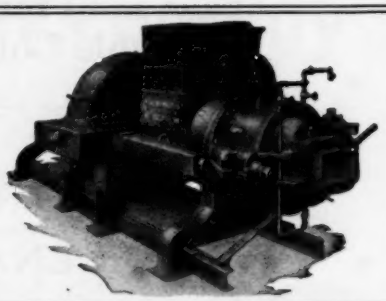

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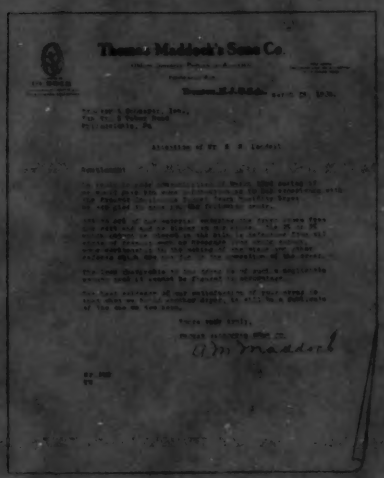

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